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TECHNICAL BULLETIN 37

DOMINION OF CANADA — DEPARTMENT OF AGRICULTURE

PHYSIOLOGICAL STUDIES WITH THE TOBACCO PLANT

by

G. M. WARD

TOBACCO DIVISION
EXPERIMENTAL FARMS SERVICE

Published by authority of the Hon. JAMES G. GARDINER, Minister of Agriculture,
Ottawa, Canada

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FOREWORD

THE material presented in this bulletin represents a large part of the results accumulated by the Tobacco Division of the Central Experimental Farm, Ottawa, on the subject of the physiology of the tobacco plant, since that work was started in 1933. The projects outlined in Parts 1 and 2 have been spread over a number of years, and certain aspects of the work are still in progress. The experiments outlined here have been constantly expanded and improved, new lines of approach have been developed, and procedures have been revised when necessary. The underlying purpose in all this work is the search for methods of improving the quality of Canadian tobacco. While it is difficult to point to any one outstanding development in this regard, nevertheless the constant accumulation of fundamental facts regarding the plant and its behaviour has helped in the framing of recommendations which are circulated regularly amongst the tobacco growers of Canada.

Grateful acknowledgment is hereby made to the following—Dr. N. T. Nelson who has directed most of the physiological work; Mr. K. G. McPhee, Mr. H. A. Horton, Mr. W. A. Scott, and other members of the staffs at the Delhi Tobacco Substation and the Harrow Experimental Station, for the collection and preparation of samples.

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PART I—MINERAL INVESTIGATIONS

SOME EFFECTS OF POTASSIUM ON CIGAR TOBACCO

Introduction

The element potassium plays a very important role in the physiological economy of the tobacco plant. It is absolutely essential to plant growth, and cannot be replaced entirely by any other element. Its physiological significance in regard to carbohydrate synthesis is extremely important, its great influence on the mineral absorption of the plant is quite evident, and its function in the combustion of tobacco has long been recognized. Consequently, much research has been done, and there is a considerable amount of literature on the subject. Anderson, Swanback, and Street (3) have published a fairly complete summary of the facts concerning potassium in Connecticut tobacco; Ames and Boltz (1) have studied the potassium content of Ohio tobacco; and many investigators have worked on the combustion problem. However, up to the present no work of the type described in this bulletin has ever been done on Canadian-grown tobacco.

In 1929 a series of fertilizer experiments was started at the Central Experimental Farm, Ottawa, by the Tobacco Division. A brief account of some of the preliminary results has been published in the various annual reports since that date (12, 13). In order to supplement the information obtained from these field tests, a physiological investigation of some of the potassium relationships in cigar tobacco was undertaken. Samples of cured and graded tobacco which were grown on plots of the "quantity of potash" series have been subjected to a chemical analysis. The results are presented and discussed in this paper.

Plot and Field Work

During the first four years of this fertilizer experiment the variety of tobacco grown was Resistant Havana, but in the fifth year, owing to a disease infection in the seed-beds, the variety was changed to Comstock Spanish. An account of the plot technique and the method of quality evaluation, i.e., the "grade index", may be found elsewhere (12).

The plot work in all the fertilizer trials was formulated on the basis of a basal ration. Table I outlines the fertilizer mixture used as a basal ration throughout the series.

TABLE I.—BASAL FERTILIZER RATION

Material	Quantity per Acre (lb.)	Nutrients per Acre		
		N (lb.)	P_2O_5 (lb.)	K_2O (lb.)
Nitrate of soda	210	32	....	....
Sulphate of ammonia	160	32	....	....
Cottonseed meal	1,420	96	40	27
Superphosphate	750	....	120	....
Sulphate of potash	360	....	....	173
Total	2,900	160	160	200

In the "quantity of potash" series varying quantities of potassium in the form of sulphate were used in the basal formula. Three different treatments were used and each treatment was applied on six separate plots, the same treatment being applied each year on the same plots throughout the first five years of the experiment. Table 2 outlines the different treatments, and table 3 is a summary of the average yield and quality of tobacco from all potash plots for the five crop years 1929 to 1933.

TABLE 2.—QUANTITY OF POTASH

Treatment No.	Treatment	Quantity of mineral K_2O
K-1	Basal formula	200 lb.
K-2	Half basal formula	100 lb.
K-3	No mineral potash	27*lb.

* From cottonseed meal used in mixture.

It will be observed from the figures in table 3 that variation in the potash fertilizer has a greater and more consistent effect on the quality of tobacco than on the yield. This is in accordance with the results of Russell at Rothamsted (15) who found that in potash-starved plants, in the presence of sufficient supplies of nitrogen, the leaf size is quite normal, but the disturbance of the physiological balance causes undesirable effects in quality and general healthiness of the plant. The figures also correspond very closely to the results obtained by Anderson, Swanback, and Street (3) with different types of tobacco in a different climate.

TABLE 3.—AVERAGE YIELD AND QUALITY FROM ALL POTASH PLOTS

Year	Average Yield per Acre			Average Grade Index		
	K-1	K-2	K-3	K-1	K-2	K-3
	lb.	lb.	lb.			
1929	1,745	1,776	1,635	23·7	23·9	21·7
1930	2,073	1,896	1,913	31·8	30·8	27·1
1931	1,840	1,832	1,672	19·3	17·6	14·5
1932	1,843	1,781	1,715	22·4	21·4	13·3
1933	1,563	1,489	1,437	23·8	22·9	16·3
5-year average	1,822	1,754	1,674	24·3	23·3	18·6

Chemical Composition of Tobacco from the Potash Plots

The chemical analysis was made on twenty samples of cured tobacco from the 1931 crop, and twelve samples from the 1932 crop. While there were eighteen plots in all devoted to the "quantity of potash" series, the samples were selected from six plots only, namely, from two plots of each of the treatments K-1, K-2, and K-3. The samples were graded in the customary manner according to colour into lights and darks, and according to the position of the leaf on the main stalk into bottoms, middles, and tops. Before further treatment the midribs were separated from the leaf tissue and labelled as individual samples. All samples, leaf and midrib, were then dried and ground in a mill, and subjected to a fairly complete mineral and nitrogen analysis. Every analysis was performed in duplicate, and all percentages are expressed on a moisture-free sand-free basis. The methods of chemical analysis employed were the official

methods of the A.O.A.C. (14) with the following exceptions. Nitrate nitrogen, and nitrogen "due to ammonia and other volatile bases except nicotine" (this constituent will be designated as "ammonia nitrogen" for the sake of brevity) were determined by the methods of Vickery and Pucher (18). Nicotine nitrogen is a calculated value, being 17·25 per cent of the total nicotine. The official silico-tungstic acid procedure was used for all nicotine determinations. The results of the analyses have been averaged in three ways—according to treatment, leaf colour, and leaf position, and are tabulated in tables 4, 5, and 6. A number of well-known relationships are confirmed, and a few new trends are shown by these figures.

TABLE 4.—PERCENTAGE COMPOSITION OF TOBACCO

AVERAGES ACCORDING TO TREATMENT

(a) Leaf—

Analysis	Treatment	1931 Crop	1932 Crop	Average
CaO	K-1	6·25	6·45	6·35
	K-2	7·18	7·43	7·31
	K-3	7·42	8·80	7·66
MgO	K-1	1·34	·90	1·12
	K-2	1·47	1·10	1·29
	K-3	1·57	1·68	1·63
P_2O_5	K-1	·49	·47	·48
	K-2	·51	·48	·50
	K-3	·53	·48	·51
K_2O	K-1	5·21	5·71	5·46
	K-2	4·78	4·49	4·64
	K-3	5·07	2·92	3·00
S	K-1	·90	·69	·80
	K-2	·75	·65	·70
	K-3	·77	·70	·74
Cl	K-1	·26	·27	·27
	K-2	·23	·15	·19
	K-3	·12	·16	·14
Total nicotine	K-1	4·63	3·00	4·77
	K-2	4·71	3·76	4·24
	K-3	5·00	3·61	4·31
Free nicotine	K-1	·80	·54	·67
	K-2	·78	·60	·69
	K-3	1·04	·50	·77
Total nitrogen	K-1	4·09	4·57	4·33
	K-2	4·36	4·81	4·59
	K-3	4·41	4·24	4·33
Nitrate nitrogen	K-1	·60	·64	·62
	K-2	·72	·47	·60
	K-3	·69	·55	·62
Nicotine nitrogen	K-1	·80	·52	·66
	K-2	·81	·65	·73
	K-3	·87	·63	·75
Ammonia nitrogen	K-1	·08	·34	·21
	K-2	·26	·66	·46
	K-3	·60	·29	·45

TABLE 4.—PERCENTAGE COMPOSITION OF TOBACCO—*Continued*

AVERAGES ACCORDING TO TREATMENT

(b) Midribs

Analysis	Treament	1931 Crop	1932 Crop	Average
CaO	K-1 K-2 K-3	4·62 5·37 6·64	4·55 5·23 7·81	4·59 5·30 6·73
MgO	K-1 K-2 K-3	1·31 1·45 1·66	·90 1·17 1·72	1·11 1·31 1·69
P_2O_5	K-1 K-2 K-3	·58 ·62 ·64	·49 ·46 ·41	·54 ·54 ·53
K_2O	K-1 K-2 K-3	10·98 9·34 7·13	11·66 9·29 5·96	11·32 9·32 6·55
S	K-1 K-2 K-3	·67 ·58 ·62	·61 ·45 ·72	·64 ·52 ·67
Cl	K-1 K-2 K-3	·57 ·28 ·22	·76 ·55 ·33	·67 ·42 ·28
Total nicotine	K-1 K-2 K-3	1·67 1·75 2·17	·75 ·68 ·62	1·21 1·22 1·40
Free nicotine	K-1 K-2 K-3	·72 ·69 ·75	·21 ·16 ·19	·47 ·42 ·47
Total nitrogen	K-1 K-2 K-3	3·12 3·17 3·23	3·14 3·23 3·02	3·13 3·20 3·13
Nitrate nitrogen	K-1 K-2 K-3	1·88 1·75 1·87	1·95 1·83 2·24	1·92 1·79 2·06
Nicotine nitrogen	K-1 K-2 K-3	·29 ·31 ·38	·13 ·12 ·11	·21 ·22 ·25
Ammonia nitrogen	K-1 K-2 K-3	·25 ·64 ·64	·46 ·58 ·63	·36 ·61 ·64

From the data presented in the above table the following conclusions can be drawn:—

1. Each increase in the quantity of potash fertilizer applied causes a corresponding increase in the percentage of potash in the leaf.

2. The percentages of CaO and MgO vary inversely as the percentage of K_2O in the leaf, and hence each increase of K_2O in the fertilizer mixture causes a corresponding decrease in the amount of CaO and MgO absorbed by the plant. This is an excellent illustration of the reciprocal base relationship found in many plants (3, 15, 16, 17).

3. There is a slight tendency for the percentage of P_2O_5 to decrease with increased potash intake. It is recognized, of course, that variations in the P_2O_5 content of tobacco are very slight. While the figures in table 4 show very small differences, they are fairly consistent except for the midribs of the 1932 tobacco.

4. The percentages of S, and Cl tend to vary directly with the potash content of the leaf and with potash fertilization. These differences are not so great nor so important as those with CaO and MgO. The tendency towards direct variation of sulphur content with potash is due, of course, to the fact that potash is applied in the form of sulphate, and hence each increase in potash fertilization involves a corresponding increase in the amount of sulphur available to the plant. The figures in the table indicate, however, that the plant is not nearly so sensitive to the sulphur changes as to variations in potash.

5. In regard to the nicotine and nitrogen percentages it will be seen that there is a tendency for these constituents to be higher in leaves containing less potash. This tendency is more evident in the 1931 crop, and also shows more clearly in the leaf tissue than in the midrib. The nitrate nitrogen figures, however, are not consistent. Regarding this inverse relationship between potassium and nitrogen in the plant, reference is again made to the work of Russell (15) and also to that of Garner and his associates (6) who found the same tendency in tobacco and other plants.

TABLE 5.—PERCENTAGE COMPOSITION

AVERAGES ACCORDING TO COLOUR

(a) Leaf—

Analysis	Treatment	1931 Crop		1932 Crop		Average	
		Lights	Darks	Lights	Darks	Lights	Darks
CaO	K-1	6·22	6·26	7·13	6·08	6·67	6·17
	K-2	8·52	6·73	8·92	6·94	8·72	6·83
	K-3	....	7·42	....	8·80	....	8·11
MgO	K-1	1·36	1·32	·65	1·03	1·01	1·18
	K-2	1·69	1·40	1·20	1·06	1·45	1·23
	K-3	....	1·57	....	1·68	....	1·63
P_2O_5	K-1	·50	·48	·43	·49	·47	·49
	K-2	·52	·51	·42	·50	·47	·51
	K-3	....	·53	....	·48	....	·51
K_2O	K-1	4·99	5·29	6·07	5·52	5·53	5·41
	K-2	4·59	4·84	4·27	4·57	4·43	4·71
	K-3	....	3·07	....	2·92	....	3·00
S	K-1	·92	·89	·68	·70	·80	·80
	K-2	·79	·74	·58	·67	·69	·71
	K-3	....	·77	....	·70	....	·74
Cl	K-1	·27	·26	·23	·29	·25	·28
	K-2	·11	·27	·13	·15	·12	·21
	K-3	....	·12	....	·16	....	·14
Total nicotine	K-1	4·97	4·51	2·96	3·01	3·97	3·76
	K-2	4·75	4·70	3·51	3·81	4·13	4·26
	K-3	....	5·00	....	3·61	....	4·31
Free nicotine	K-1	·82	·79	·54	·53	·68	·66
	K-2	·63	·83	·57	·60	·60	·72
	K-3	....	1·04	....	·50	....	·77
Total nitrogen	K-1	3·99	4·13	3·84	4·93	3·92	4·53
	K-2	4·21	4·41	4·30	4·94	4·25	4·68
	K-3	....	4·41	....	4·24	....	4·33
Nitrate nitrogen	K-1	·64	·59	·74	·60	·69	·60
	K-2	·67	·74	·73	·38	·70	·56
	K-3	....	·69	....	·55	....	·62
Nicotine nitrogen	K-1	·86	·78	·51	·52	·69	·65
	K-2	·82	·81	·60	·66	·71	·74
	K-3	....	·87	....	·63	....	·75
Ammonia nitrogen	K-1	·07	·08	·21	·40	·14	·24
	K-2	·21	·28	·16	·82	·19	·55
	K-3	....	·60	....	·29	....	·45

TABLE 5.—PERCENTAGE COMPOSITION—*Concluded*

AVERAGES ACCORDING TO COLOUR

(b) Midrib—

Analysis	Treatment	1931 Crop		1932 Crop		Average	
		Lights	Darks	Lights	Darks	Lights	Darks
CaO	K-1	4·83	4·55	4·71	4·47	4·77	4·51
	K-2	5·96	5·17	5·49	5·14	5·73	5·16
	K-3	....	6·64	....	7·81	....	7·23
MgO	K-1	1·33	1·30	·94	·89	1·14	1·10
	K-2	1·61	1·40	1·35	1·11	1·48	1·26
	K-3	....	·64	....	·41	....	·53
P_2O_5	K-1	·67	·55	·36	·56	·52	·56
	K-2	·72	·58	·37	·48	·55	·53
	K-3	....	·64	....	·41	....	·53
K_2O	K-1	10·91	11·00	11·99	11·34	11·45	11·17
	K-2	8·76	9·53	6·70	10·23	7·73	9·88
	K-3	....	7·13	....	5·96	....	6·55
S	K-1	·67	·66	·62	·60	·65	·63
	K-2	·72	·54	·46	·44	·59	·49
	K-3	....	·62	....	·72	....	·67
Cl	K-1	·55	·58	·81	·74	·68	·66
	K-2	·20	·30	·55	·55	·38	·43
	K-3	....	·22	....	·33	....	·28
Total nicotine	K-1	1·63	1·68	·58	·83	1·11	1·26
	K-2	1·71	1·77	·57	·72	1·14	1·25
	K-3	....	2·17	....	·62	....	1·40
Free nicotine	K-1	·67	·74	·22	·21	·45	·48
	K-2	·74	·68	·17	·16	·46	·42
	K-3	....	·75	....	·19	....	·47
Total nitrogen	K-1	3·00	3·14	3·27	3·07	3·14	3·11
	K-2	3·23	3·16	2·98	3·31	3·11	3·24
	K-3	....	3·23	....	3·02	....	3·13
Nitrate nitrogen	K-1	2·09	1·81	2·19	1·84	2·14	1·83
	K-2	1·99	1·67	1·53	1·93	1·76	1·80
	K-3	....	1·87	....	2·24	....	2·06
Nicotine nitrogen	K-1	·29	·29	·10	·15	·20	·22
	K-2	·30	·31	·10	·12	·20	·22
	K-3	....	·38	....	·11	....	·25
Ammonia nitrogen	K-1	·26	·24	·59	·40	·43	·32
	K-2	·80	·58	·40	·63	·60	·61
	K-3	....	·64	....	·63	....	·64

The following conclusions may be drawn from table 5:—

1. Light leaves contain a higher percentage of CaO, MgO, and possibly S, than dark leaves.

2. Dark leaves contain a higher percentage of total nicotine, total nitrogen, nicotine nitrogen, and ammonia nitrogen. The nitrogen figures are not so consistent in the midrib, and free nicotine shows no direct relation. This result is in accordance with the findings of many investigators (6) who have shown that thick, dark-coloured leaves are always associated with high percentages of nitrogen and nitrogen compounds.

3. K_2O, P_2O_5, and Cl show no consistent relation to leaf colour.

4. There is a slight tendency for light leaves to contain a higher percentage of nitrates.

TABLE 6.—PERCENTAGE COMPOSITION

AVERAGES ACCORDING TO LEAF-POSITION

(a) Leaf—

Analysis	Treatment	1931 Crop			1932 Crop*		Average		
		Botts	Mids	Tops	Mids	Tops	Botts	Mids	Tops
CaO..........	K-1	7·61	6·13	5·12	6·92	5·52	7·61	6·52	5·32
	K-2	7·42	7·75	5·80	7·89	6·98	7·42	7·82	6·39
	K-3	....	8·32	6·52	8·80	....	....	8·56	6·52
MgO.........	K-1	1·48	1·34	1·22	·87	·97	1·48	1·11	1·10
	K-2	1·52	1·54	1·28	1·21	·99	1·52	1·37	1·14
	K-3	....	1·74	1·40	1·68	....	....	1·71	1·40
P_2O_5..........	K-1	·45	·46	·58	·41	·58	·45	·44	·52
	K-2	·49	·50	·55	·42	·54	·49	·46	·52
	K-3	....	·49	·56	·48	....	....	·49	·56
K_2O..........	K-1	5·52	5·76	4·82	5·85	5·41	5·52	5·55	5·12
	K-2	5·23	4·40	5·08	4·68	4·31	5·23	4·54	4·70
	K-3	....	2·80	3·34	2·92	....	....	2·86	3·34
S.............	K-1	·75	·94	·97	·68	·71	·75	·81	·84
	K-2	·67	·77	·80	·59	·71	·67	·68	·76
	K-3	....	·73	·88	·70	....	....	·72	·88
Cl............	K-1	·25	·23	·35	·25	·31	·25	·24	·33
	K-2	·38	·12	·28	·17	·13	·38	·15	·21
	K-3	....	·10	·14	·16	....	....	·13	·14
Total nicotine.	K-1	3·69	4·69	5·45	2·89	3·21	3·69	3·79	4·33
	K-2	3·95	4·89	5·10	3·62	3·85	3·95	4·26	4·48
	K-3	....	4·99	5·01	3·61	....	....	4·30	5·01
Free nicotine.	K-1	·78	·81	·81	·55	·52	·78	·68	·67
	K-2	·68	·75	·92	·60	·59	·68	·68	·76
	K-3	....	·98	1·10	·50	....	....	·74	1·10
Total nitrogen.	K-1	3·09	4·13	5·01	3·97	5·76	3·09	4·05	5·39
	K-2	3·39	4·36	5·32	4·35	5·27	3·39	4·36	5·30
	K-3	....	3·78	5·05	4·24	....	....	4·01	5·05
Nitrate nitrogen.	K-1	·56	·60	·65	·63	·68	·56	·62	·67
	K-2	·73	·71	·74	·62	·31	·73	·67	·53
	K-3	....	·61	·77	·55	....	....	·58	·77
Nicotine nitrogen.	K-1	·65	·82	·93	·45	·56	·65	·64	·75
	K-2	·69	·84	·88	·63	·67	·69	·74	·78
	K-3	....	·87	·87	·63	....	....	·75	·87
Ammonia nitrogen.	K-1	·10	·06	·09	·15	·72	·10	·11	·41
	K-2	·25	·43	·37	·31	1·01	·25	·37	·69
	K-3	....	·49	·71	·29	....	....	·39	·71

(b) Midrib—

Analysis	Treatment	1931 Botts	1931 Mids	1931 Tops	1932 Mids	1932 Tops	Average Botts	Average Mids	Average Tops
CaO..........	K-1	5·30	4·61	4·01	4·82	4·01	5·30	4·72	4·01
	K-2	5·58	5·67	4·54	5·55	4·91	5·58	4·61	4·73
	K-3	....	6·68	6·60	7·81	....	....	7·25	6·60
MgO.........	K-1	1·40	1·25	1·30	·97	·77	1·40	1·11	1·18
	K-2	1·43	1·54	1·30	1·30	1·05	1·43	1·42	1·18
	K-3	....	1·69	1·64	1·72	....	....	1·71	1·64
P_2O_5..........	K-1	·49	·61	·61	·40	·68	·49	·51	·65
	K-2	·63	·69	·47	·39	·53	·63	·54	·50
	K-3	....	·62	·66	·41	....	....	·52	·66
K_2O..........	K-1	12·09	10·95	9·92	11·66	....	12·09	11·31	9·92
	K-2	11·33	8·66	8·73	8·43	10·16	11·33	8·55	9·34
	K-3	....	7·03	7·23	5·96	....	....	6·50	7·23

* Bottom leaves discarded in 1932 Crop.

TABLE 6.—PERCENTAGE COMPOSITION—*Concluded*

AVERAGES ACCORDING TO LEAF-POSITION

(*b*) *Midrib*—concluded

Analysis	Treatment	1931 Crop			1932 Crop*		Average		
		Botts	Mids	Tops	Mids	Tops	Botts	Mids	Tops
S............	K-1	·67	·66	·67	·63	·56	·67	·65	·62
	K-2	·43	·70	·51	·49	·42	·43	·60	·47
	K-3	....	·61	·64	·70	....	....	·66	·64
Cl............	K-1	·65	·53	·58	·82	·65	·65	·68	·62
	K-2	·34	·24	·29	·53	·57	·34	·39	·43
	K-3	....	·23	·21	·33	....	....	·28	·21
Total nicotine.	K-1	1·34	1·55	2·24	·59	1·05	1·34	1·07	1·65
	K-2	1·37	1·75	2·15	·58	·78	1·37	1·17	1·47
	K-3	....	2·31	2·03	·62	....	....	1·47	2·03
Free nicotine.	K-1	·72	·71	·80	·20	·24	·72	·46	·52
	K-2	·55	·71	·80	·19	·14	·55	·45	·47
	K-3	....	·87	·63	·19	....	....	·53	·63
Total nitrogen.	K-1	2·95	2·99	3·32	2·99	3·43	2·93	2·99	3·48
	K-2	2·91	3·14	3·51	2·95	3·51	2·91	3·05	3·51
	K-3	....	3·14	3·31	3·02	....	....	3·08	3·31
Nitrate nitrogen.	K-1	1·93	2·07	1·43	2·06	1·74	1·93	2·07	1·59
	K-2	1·77	1·81	1·62	1·86	1·81	1·77	1·84	1·72
	K-3	....	2·04	1·70	2·24	....	....	2·14	1·70
Nicotine nitrogen.	K-1	·23	·27	·39	·11	·19	·23	·19	·29
	K-2	·24	·31	·37	·11	·13	·24	·21	·25
	K-3	....	·40	·30	·11	....	....	·26	·30
Ammonia nitrogen.	K-1	·23	·23	·30	·38	·63	·23	·31	·47
	K-2	·26	·77	·75	·41	·75	·26	·59	·75
	K-3	....	·71	·57	·63	....	....	·67	·57

* Bottom leaves discarded in 1932 Crop.

The following conclusions may be drawn from table 6:—

1. In passing from the bottom of the plant to the top there is an increase in the content of P_2O_5, S, N, and nicotine constituents.

2. In passing from the bottom to the top of the plant there is a decrease in the content of CaO, MgO, and K_2O.

3. The Cl content of the leaf is not affected by the position of the leaf on the stalk.

A closer inspection of tables 4, 5, and 6 will reveal a number of general tendencies. It will be seen that the total nicotine percentage always varies directly with the total nitrogen. This is a very sensitive relation, and the slightest change in nitrogen content is immediately reflected in the nicotine figure. Potash, nitrates, and chlorine are always much more abundant in the midrib than in the leaf tissue, while the nicotine figure is always higher for the leaf. The P_2O_5 content of tobacco tends to remain more constant than that of any other constituent.

The Calcium-Magnesium Ratio

Reference has already been made to the reciprocal base relationship illustrated by the figures in table 4. This is an important factor in the tobacco leaf. In all cases recorded in the table, both calcium and magnesium show a decidedly antagonistic effect towards potassium; also, the sum of CaO + MgO increases regularly with each decrease in potash content of the leaf. The calcium-

magnesium ratio, however, is another phase of this problem and has been closely investigated by Garner and associates (5). Table 7 is a summary of the Ca-Mg ratio of the samples in the present series. The values in table 7 were obtained from the figures in table 4.

TABLE 7.—THE CALCIUM-MAGNESIUM RATIO

Treatment	Leaf			Midrib		
	1931	1932	Average	1931	1932	Average
K-1	4·66	7·16	5·91	3·52	5·05	4·28
K-2	4·88	6·75	5·82	3·70	4·47	4·09
K-3	4·72	5·23	4·98	4·00	4·54	4·27

The data presented above indicate that there is apparently no consistent relation between potash intake and the calcium-magnesium ratio of tobacco. Although the sum of CaO + MgO is very sensitive to any change in potash, the ratio between the two tends to remain fairly constant.

Soil Analysis

In order to obtain more complete data on the problem of potassium in tobacco, a chemical analysis was made of samples of soil from twelve of the above-mentioned eighteen potash plots at the end of the fifth year of the fertilizer experiment (1933). Table 8 gives the result of this analysis and compares these figures with the yield and grade index of the tobacco grown on each plot in 1933. Replaceable potash was determined by the method of Volk and Truog (19).

TABLE 8.—SOIL ANALYSIS—COMPARISON WITH CROP DATA

Plot No.	Treatment	Total K_2O %	Replace-able K_2O %	Yield 1933 Tobacco	Grade Index 1933 Tobacco
R2-38	K-1	·319	·022	1,470	21·66
R2-40	K-2	·236	·013	1,446	20·31
R2-39	K-3	·251	·007	1,698	18·07
R2-10	K-1	·396	·016	1,506	25·94
R3-10	K-2	·357	·011	1,410	21·23
R3-9	K-3	·323	·011	1,344	14·58
R6-14	K-1	·415	·015	1,500	26·76
R6-16	K-2	·319	·010	1,284	23·06
R6-15	K-3	·275	·006	1,278	17·87
R6-18	K-1	·265	·012	1,632	22·83
R6-20	K-2	·227	·012	1,596	20·09
R6-19	K-3	·188	·011	1,716	19·09

It will be seen from table 8 that the replaceable potash in the soil tends to vary directly with the fertilizer application. This is due to the continuous repetition of the same fertilizer treatment on the same plots over the five-year period. The total supply of potash in the soil is abundant, but it exists largely in fixed form unavailable for plant use (8, 19).

There is also some evidence here of the relationship between abundance of replaceable potash in the soil and high quality tobacco. In each of the four comparisons and particularly the first one, the plots which contain high replaceable K_2O readily available for plant use are the ones which produce the highest quality tobacco. High replaceable K_2O is also reflected, but to a lesser degree, in increased yields of tobacco.

Effect of Rainfall on the Chemical Composition of Tobacco

Several investigators have found that the potash content of plants varies over a period of years with the seasonal changes, being higher during seasons of heavy rainfall (2, 3). The years 1931 and 1932 were excellent years for such a comparison since 1931 was an exceptionally dry year and 1932 was a wet year. These are the only two years for which a chemical analysis of the tobacco has been completed, and table 9 compares the potash content of the leaves with the number of inches of rainfall from June 1 to Sept. 10, which is approximately the length of time the plants were in the field.

TABLE 9.—COMPARISON OF POTASH CONTENT OF TOBACCO WITH RAINFALL

Year	Rainfall in inches	K_2O Content of Tobacco					
		K-1		K-2		K-3	
		Leaf	Midrib	Leaf	Midrib	Leaf	Midrib
1931	4·78	5·21	10·98	4·78	9·34	3·07	7·13
1932	11·83	5·71	11·66	4·49	9·29	2·92	5·96

From the above figures it will be seen that there is no consistent agreement with the results found elsewhere. The K-1 treatment shows more potash with the heavier rainfall, but the K-2 and K-3 treatments do not agree with this result. However, more data are required before definite conclusions can be drawn. A study of the figures in table 7 will indicate that the calcium-magnesium ratio is apparently affected by the rainfall, and it will be seen that in a wet season the plant tends to take up relatively more calcium than magnesium. This is doubtless connected with the relative availabilities of Ca and Mg in wet and dry seasons, caused in turn by the relative rates of leaching of these elements from the soil. It is believed that the tobacco disorder known as "sand-drown", which is due to magnesium deficiency and which is more prevalent in wet seasons, is definitely connected with this physiological condition of the plant. For further comparison of the percentage composition of the 1931 and 1932 crops with rainfall, reference should be made to table 4.

Burn Tests

It has been found by many investigators (3, 4, 7, 9, 10, 16) that potassium has a very decided effect upon the combustion of tobacco. The generally accepted theory is that an increase in potash content causes a corresponding increase in fire-holding capacity, and this has been confirmed by certain very specific and definite experiments (3). A number of burn tests were made on the 1931 crop from the potash plots of the present series, with the result that this general idea was again confirmed. A test was made on 40 samples from each of the 18 potash plots mentioned previously, making a total of 240 tests for each treatment. The general averages according to treatment are presented in table 10.

TABLE 10.—BURN TESTS 1931 CROP

Treatment	Duration of Burn (in seconds)
K-1	12·5
K-2	10·8
K-3	4·7

Although there were individual exceptions, the general averages indicate that potash prolongs the duration of the burn in tobacco, and the greater the potash content, the greater is the fire-holding capacity. There is also some evidence to show that fire-holding capacity may be related to replaceable soil potash, and to soil type, but more data are required on this phase of the problem before any definite statement can be made.

Summary

1. In a five-year series of fertilizer experiments it is shown that variations in the amount of potash applied as fertilizer have a greater effect on the quality than on the quantity of tobacco produced.
2. Chemical analysis of tobacco leaves from the potash plots indicates that increasing the amount of K_2O in the fertilizer causes a corresponding increase in the percentage of K_2O, S, and Cl in the leaf, and a decrease in the percentage of CaO, MgO, P_2O_5, N, and compounds of nitrogen.
3. CaO, MgO, and S are more abundant in light-coloured leaves than in dark ones while dark leaves contain more nitrogen and related compounds.
4. P_2O_5, S, and N are more abundant in the upper parts of the plants, while CaO, MgO, and K_2O are found in greater quantities near the base of the plant.
5. The calcium-magnesium ratio is unaffected by potash fertilization.
6. Soil analysis shows more available potash in the high potash plots, which is directly reflected in improved quality.
7. The relation between potash content of the leaf and rainfall is not consistent, but the Ca-Mg ratio is higher in a wet season than a dry one.
8. Burn tests confirm the general theory that increases in potash content of tobacco cause increases in fire-holding capacity.

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SOME EFFECTS OF PHOSPHORUS ON CIGAR TOBACCO

Introduction

The importance of the element phosphorus in the culture of tobacco is now well recognized, and along with potassium and nitrogen, it is absolutely essential for the production of a crop of good yield and quality. Phosphorus is vitally connected with the growth of the plant, particularly with the process of mitotic cell division in the rapidly growing parts, and also with the production of buds and seeds, which are known to contain relatively large percentages of this element (10). The literature on the subject of phosphorus in tobacco is not nearly so extensive as that on potassium, but a considerable amount of work is being carried on at the present time, particularly in regard to phosphorus fertilizers and soil requirements (3, 5).

This paper is an account of a physiological investigation of phosphorus in the cigar tobacco plant, carried out in conjunction with a fertilizer trial, the "quantity of phosphorus" series.

Plot and Field Work

The arrangement of this experiment is much the same as that of the potassium experiment presented in the first paper of this bulletin. The details of the field and plot work in this fertilizer trial are precisely the same as for the potash experiment as described on page 7. The basal ration used in fertilizing the crop has already been outlined in table 1 of the previous paper.

The amount of P_2O_5 in the fertilizer mixture was controlled by varying the quantities of superphosphate applied to the different plots, and at the same time keeping the quantities of potassium and nitrogen constant. Four different phosphorus treatments were used in this series—the basal treatment, one with a larger quantity of phosphorus, and two with smaller quantities; each treatment was applied on four plots. The experiment was started in 1929 and continued for several years on the same plots. During the first five years of the experiment the variety of tobacco grown was Resistant Havana, but in the fifth year, owing to a disease infection in the seed-beds, the variety was changed to Comstock Spanish. An account of the plot technique and the method of quality evaluation, i.e.—the "grade index" may be found elsewhere (7, 8). Table 1 outlines the different treatments that were applied annually, and table 2 is a review of the average yields and grade indices obtained for each treatment each year until 1933.

TABLE 1.—QUANTITY OF PHOSPHORUS

Treatment No.	Treatment	Quantity of P_2O_5
P3	No mineral P_2O_5	40 lb.*
P2	Half basal ration	80 "
P1	Basal formula	160 "
P4	Double basal formula	320 "

* From cottonseed meal used in mixture.

The figures in table 2 give some indication of the important effect which phosphorus has on both the yield and quality of tobacco. In practically all cases the increased quantity of P_2O_5 in the fertilizer has an advantageous effect,

TABLE 2.—AVERAGE YIELD AND QUALITY FROM ALL PHOSPHORUS PLOTS

Year	Average Yield per Acre				Average Grade Index			
	P3	P2	P1	P4	P3	P2	P1	P4
1929	1,323	1,603	1,633	1,880	19·4	21·9	23·3	22·0
1930	1,612	1,819	2,050	2,022	30·2	32·2	31·5	31·9
1931	1,440	1,906	2,102	2,186	18·1	19·3	20·5	17·9
1932	1,494	1,805	1,928	1,986	16·9	25·8	24·7	22·6
1933	1,146	1,536	1,484	1,641	16·5	22·3	25·6	20·2

with the one exception that doubling the basal ration has a detrimental effect on quality. Thus it appears that in order to obtain a crop of good quality value, phosphorus must be supplied in available form up to a certain optimum quantity, but further additions beyond this amount will cause a marked falling off in the grade index, even although the yield may be still further increased. This optimum quantity of phosphorus for cigar tobacco corresponds very closely to basal ration used in this experiment.

Chemical Composition of Tobacco from the Phosphorus Plots

The procedure in the chemical analysis of samples from the "quantity of phosphorus" plots was essentially the same as that used in the potash experiment. Twenty-five samples from the 1931 crop were analysed and forty-seven samples from the 1932 crop, these samples being selected in order to be representative of the plants from each treatment. The samples were graded as before according to colour into lights and darks, and according to leaf position into bottoms, middles and tops. In all cases the leaves were stripped before analysis, and leaves and midribs were analysed separately. The methods of analysis are the same as in the former experiment. On the 1932 crop the analysis was extended to include the determination of ash, $Fe_2O_3 + Al_2O_3$ by the A.O.A.C. standard method (9), Na_2O by the uranyl zinc acetate method (1, 2) and Mn_3O_4 by the colorimetric periodate method (11). Mn_3O_4 and Na_2O were determined for the leaf tissue only since the traces found in the midribs were too small for comparison. Results are all expressed on a moisture-free, and sand-free basis. Nitrogen "due to ammonia and other volatile bases except nicotine", is designated in the tables as "ammonia nitrogen" for the sake of brevity.

The results of the analyses have been averaged according to treatment, leaf colour, and leaf position, and are presented in tables 3, 4, and 5.

From table 3 the following conclusions can be drawn:—

1. Every increase in fertilizer application causes a corresponding increase in the phosphorus content of the plant. This increase is only very slight, however, and it is most noticeable when the basal ration is doubled.

2. The percentages of CaO and S also increase in direct proportion to increases in the fertilizer application. This of course is due to the fact that the experiment was controlled by varying the quantity of superphosphate, which contains appreciable quantities of both CaO and S. And consequently every increase in the amount of superphosphate used involves a corresponding increase in the amount of CaO and S available to the plant.

3. The only other element which increases in percentage with increased phosphorus application is Cl, which shows a definite increase except in the P-4 treatment.

4. The following constituents decrease in percentage in proportion to increasing phosphorus application—total ash except in the P-4 treatment, $Fe_2O_3 + Al_2O_3$, K_2O especially in the midribs and top leaves, Na_2O, and total nitrogen which gives a slight indication of a decrease.

TABLE 3.—PERCENTAGE COMPOSITION—AVERAGES ACCORDING TO TREATMENT

Analysis	Treatment	1931 Crop		1932 Crop		Analysis	Treatment	1931 Crop		1932 Crop	
		Leaf	Midrib	Leaf	Midrib			Leaf	Midrib	Leaf	Midrib
Ash	P-3	...	...	27·88	27·70	Cl	P-3	·23	·54	·25	·67
	P-2	...	...	27·28	27·01		P-2	·24	·52	·31	·78
	P-1	...	...	24·20	27·00		P-1	·32	·80	·35	·90
	P-4	...	...	25·03	27·02		P-4	·31	·71	·28	·68
$Fe_2O_3 + Al_2O_3$	P-3	...	...	1·22	·91	Mn_3O_4	P-3	...	...	·020	...
	P-2	...	...	1·15	1·02		P-2	...	...	·020	...
	P-1	...	...	1·00	·59		P-1	...	...	·019	...
	P-4	...	...	1·02	·57		P-4	...	...	·026	...
CaO	P-3	5·98	4·17	5·40	3·78	Total nicotine	P-3	3·75	1·67	2·88	·88
	P-2	6·03	4·16	5·85	4·15		P-2	3·73	1·48	3·14	·99
	P-1	6·82	4·83	6·08	4·17		P-1	3·73	1·35	3·11	·92
	P-4	6·63	4·60	6·22	4·34		P-4	·85	·70	·74	·37
MgO	P-3	1·30	1·23	1·20	·96	Free nicotine	P-3	·90	·65	·62	·28
	P-2	1·18	1·14	1·13	1·06		P-2	·76	·61	·65	·33
	P-1	1·39	1·32	1·15	1·00		P-1	·85	·57	·71	·32
	P-4	1·40	1·24	1·13	1·05		P-4	·85	·70	·74	·37
P_2O_5	P-3	·42	·40	·40	·48	Total nitrogen	P-3	4·40	3·02	4·47	3·12
	P-2	·42	·44	·56	·52		P-2	4·17	2·75	4·46	2·98
	P-1	·44	·54	·54	·59		P-1	4·04	2·81	4·43	2·81
	P-4	·54	·67	·54	·63		P-4	4·47	2·97	4·11	2·81
K_2O	P-3	6·01	11·52	6·23	12·01	Nitrate nitrogen	P-3	·72	1·46	·36	1·61
	P-2	6·39	11·13	6·11	12·01		P-2	·52	1·21	·66	1·97
	P-1	6·10	10·91	5·82	11·92		P-1	·49	1·50	·50	1·99
	P-4	5·90	9·87	5·36	11·42		P-4	·64	1·56	·58	1·92
Na_2O	P-3	...	...	·089	...	Nicotine nitrogen	P-3	·65	·29	·50	·15
	P-2	...	...	·074	...		P-2	·65	·26	·54	·17
	P-1	...	...	·050	...		P-1	·65	·22	·54	·17
	P-4	...	...	·041	...		P-4	·67	·32	·61	·18
S	P-3	·94	·70	·94	·73	Ammonia nitrogen	P-3	·68	·74	·24	·76
	P-2	1·09	·76	·88	·92		P-2	·70	·72	·24	·53
	P-1	1·22	·94	1·03	·91		P-1	·67	·80	·28	·64
	P-4	1·48	1·01	1·16	·97		P-4	·68	·58	·44	·61

TABLE 4.—PERCENTAGE COMPOSITION—AVERAGES ACCORDING TO LEAF-COLOUR

Analysis	Treatment	1931 Crop				1932 Crop			
		Leaf		Midrib		Leaf		Midrib	
		Light	Dark	Light	Dark	Light	Dark	Light	Dark
Ash.......	P-3	....	....	....	....	32·38	26·47	30·76	26·39
	P-2	....	....	....	....	29·80	24·77	28·61	25·41
	P-1	....	....	....	....	24·70	23·77	28·80	25·47
	P-4	....	....	....	....	26·40	24·35	28·62	26·23
Fe_2O_3 + Al_2O_3	P-3	....	....	....	....	1·34	1·16	·91	·91
	P-2	....	....	....	....	1·27	1·03	1·09	·95
	P-1	....	....	....	....	1·03	·97	·39	·75
	P-4	....	....	....	....	1·00	1·04	·48	·62
CaO.......	P-3	6·60	5·73	4·63	3·98	6·09	5·10	4·28	3·56
	P-2	6·43	5·73	4·45	3·94	6·58	5·13	4·51	3·80
	P-1	7·31	6·18	4·91	4·40	6·72	5·53	4·62	3·79
	P-4	7·79	6·24	5·23	4·39	6·59	6·03	4·62	4·21
MgO......	P-3	1·32	1·39	1·27	1·21	1·36	1·13	·99	·94
	P-2	1·15	1·20	1·16	1·13	1·17	1·08	1·10	1·02
	P-1	1·45	1·31	1·31	1·30	1·20	1·10	1·00	1·01
	P-4	1·51	1·33	1·30	1·22	1·18	1·10	1·06	1·05
P_2O_5.......	P-3	·47	·40	·42	·29	·28	·45	·32	·55
	P-2	·37	·47	·41	·47	·47	·66	·37	·66
	P-1	·39	·50	·51	·57	·46	·60	·44	·71
	P-4	·52	·54	·75	·64	·48	·57	·51	·69
K_2O.......	P-3	6·58	6·18	11·96	11·35	6·38	6·16	12·67	11·72
	P-2	6·58	6·23	11·94	10·52	6·04	6·17	12·48	11·53
	P-1	6·23	5·93	11·51	10·11	6·00	5·66	12·55	11·62
	P-4	6·38	5·73	11·47	9·34	5·52	5·28	12·30	10·99
Na_2O......	P-3	....	....	....	....	·110	·080	....	....
	P-2	....	....	....	....	·099	·048	....	....
	P-1	....	....	....	....	·044	·055	....	....
	P-4	....	....	....	....	·041	·041	....	....
S..........	P-3	·91	·96	·72	·69	·98	·93	·78	·72
	P-2	1·11	1·07	·78	·75	·87	·88	1·01	·84
	P-1	1·17	1·29	·90	·99	·99	1·06	·95	·88
	P-4	1·40	1·50	·98	1·02	1·12	1·19	1·00	·95

Analysis	Treatment	1931 Crop				1932 Crop			
		Leaf		Midrib		Leaf		Midrib	
		Light	Dark	Light	Dark	Light	Dark	Light	Dark
Cl.........	P-3	·20	·25	·44	·59	·20	·27	·58	·71
	P-2	·23	·24	·50	·55	·28	·34	·79	·77
	P-1	·33	·30	·84	·75	·32	·37	·90	·91
	P-4	·30	·31	·92	·70	·26	·29	·66	·68
Mn_3O_4.....	P-3	....	....	....	....	·019	·021	....	....
	P-2	....	....	....	....	·023	·018	....	....
	P-1	....	....	....	....	·020	·019	....	....
	P-4	....	....	....	....	·026	·026	....	....
Total nicotine	P-3	3·15	3·99	1·92	1·56	2·69	2·96	·77	·92
	P-2	3·40	3·98	1·23	1·68	2·92	3·37	·87	1·11
	P-1	3·40	4·16	1·09	1·46	2·84	3·31	·75	1·06
	P-4	3·15	4·08	1·28	1·97	3·43	3·55	·89	1·06
Free nicotine	P-3	·83	·94	·63	·66	·67	·59	·33	·26
	P-2	·76	·78	·70	·55	·71	·59	·34	·31
	P-1	·99	·91	·59	·55	·72	·69	·32	·32
	P-4	·89	·84	·78	·67	·77	·72	·41	·36
Total nitrogen	P-3	3·95	4·59	2·78	3·12	3·64	4·83	2·85	3·17
	P-2	3·73	4·51	2·64	2·28	3·96	4·97	2·60	3·19
	P-1	3·63	4·59	2·76	2·92	3·92	4·82	2·49	3·11
	P-4	3·74	4·71	2·58	3·09	3·71	4·31	2·60	2·92
Nitrate nitrogen	P-3	·85	·67	1·59	1·37	·32	·37	1·59	1·61
	P-2	·52	·51	1·25	1·19	·73	·60	2·07	1·86
	P-1	·50	·48	1·64	1·33	·54	·48	2·12	1·88
	P-4	·82	·57	2·22	1·34	·74	·50	2·41	1·68
Nicotine nitrogen	P-3	·55	·69	·33	·27	·47	·51	·13	·16
	P-2	·59	·69	·22	·29	·51	·58	·15	·19
	P-1	·59	·72	·19	·27	·50	·57	·14	·19
	P-4	·55	·71	·23	·35	·60	·61	·16	·19
Ammonia nitrogen	P-3	·71	·67	·67	·77	·13	·29	·63	·82
	P-2	·58	·79	·73	·72	·07	·41	·36	·71
	P-1	·62	·73	·71	·92	·16	·38	·53	·71
	P-4	·61	·70	·48	·61	·26	·53	·45	·69

TABLE 5.—PERCENTAGE COMPOSITION—AVERAGES ACCORDING TO LEAF POSITION

Analysis	Treatment	1931 Crop						1932 Crop					
		Leaf			Midrib			Leaf			Midrib		
		Bott.	Mid.	Top	Bott.	Mid.	Top	Bott.	Mid.	Top	Bott.	Mid.	Top
Ash	P-3	....	....	....	....	....	....	28·19	27·60	24·48	32·34	27·55	24·86
	P-2	....	....	....	....	....	....	32·48	27·98	23·63	32·43	27·40	24·42
	P-1	....	....	....	....	....	....	23·14	26·00	23·03	32·06	27·10	24·32
	P-4	....	....	....	....	....	....	....	26·00	23·09	....	29·56	24·45
$Fe_2O_3 + Al_2O_3$	P-3	....	....	....	....	....	....	1·24	1·17	1·27	1·13	·77	1·00
	P-2	....	....	....	....	....	....	1·51	1·07	1·09	1·02	·97	1·09
	P-1	....	....	....	....	....	....	1·14	·97	·97	·33	·46	·94
	P-4	....	....	....	....	....	....	....	·96	1·13	....	·50	·72
CaO	P-3	7·04	5·90	5·05	4·85	4·19	3·45	6·90	5·36	4·45	4·87	3·76	3·09
	P-2	7·34	6·12	5·18	5·16	4·15	3·68	7·63	5·89	4·92	5·21	4·24	3·49
	P-1	7·75	6·69	5·53	5·02	4·63	4·29	7·81	6·22	4·97	5·19	4·36	3·58
	P-4	....	7·33	5·92	....	5·10	4·11	....	6·63	5·39	....	4·68	3·48
MgO	P-3	1·32	1·35	1·20	1·36	1·21	1·12	1·35	1·23	1·07	1·03	·99	·86
	P-2	1·13	1·22	1·13	1·25	1·14	1·10	1·21	1·17	1·03	1·03	1·11	·99
	P-1	1·55	1·38	1·10	1·25	1·37	1·26	1·22	1·22	·99	·96	1·05	·95
	P-4	....	1·43	1·32	....	1·31	1·18	....	1·15	1·08	....	1·10	·96
P_2O_5	P-3	·30	·38	·53	·37	·41	·42	·26	·39	·51	·25	·43	·70
	P-2	·23	·44	·50	·36	·42	·53	·35	·52	·75	·21	·46	·76
	P-1	·34	·47	·53	·46	·57	·58	·33	·53	·67	·25	·54	·83
	P-4	....	·53	·55	....	·70	·64	....	·47	·67	....	·54	·82
K_2O	P-3	5·70	6·01	6·32	11·97	11·69	11·07	6·66	6·13	6·09	13·40	11·83	11·38
	P-2	6·22	6·54	6·19	12·29	11·41	10·00	6·49	5·83	6·33	13·40	11·94	11·41
	P-1	6·21	6·21	5·44	11·67	10·96	9·20	6·52	5·62	5·82	13·80	11·73	11·31
	P-4	....	6·00	5·79	....	11·09	8·66	....	5·27	5·55	....	11·86	10·54
Na_2O	P-3	....	....	....	....	....	....	·115	·076	·093	....	....	....
	P-2	....	....	....	....	....	....	·034	·107	·043	....	....	....
	P-1	....	....	....	....	....	....	·065	·039	·062	....	....	....
	P-4	....	....	....	....	....	....	....	·041	·041	....	....	....
S	P-3	·88	·93	1·04	·77	·68	·65	·81	·96	1·02	·79	·70	·75
	P-2	·97	1·12	1·10	·69	·79	·75	·59	·98	·87	1·12	·95	·81
	P-1	1·17	1·26	1·20	·95	·93	·97	·81	1·07	1·06	·94	·93	·88
	P-4	....	1·44	1·52	....	1·00	1·03	....	1·13	1·24	....	1·00	·91

TABLE 5.—PERCENTAGE COMPOSITION—AVERAGES ACCORDING TO LEAF POSITION—*Concluded*

Analysis	Treatment	1931 Crop						1932 Crop					
		Leaf			Midrib			Leaf			Midrib		
		Bott.	Mid.	Top	Bott.	Mid.	Top	Bott.	Mid.	Top	Bott.	Mid.	Top
Cl	P-3	·17	·25	·31	·45	·59	·54	·27	·24	·26	·53	·68	·74
	P-2	·23	·23	·26	·41	·53	·57	·28	·30	·33	·94	·77	·72
	P-1	·32	·30	·40	·88	·74	·89	·32	·33	·40	·94	·91	·88
	P-4	....	·28	·33	....	·68	·74	....	·27	·31	....	·68	·66
Mn_3O_4	P-3	....	....	....	....	....	....	·026	·018	·020	....	....	....
	P-2	....	....	....	....	....	....	·027	·020	·018	....	....	....
	P-1	....	....	....	....	....	....	·027	·021	·014	....	....	....
	P-4	....	....	....	....	....	....	....	·027	·023	....	....	....
Total nicotine	P-3	3·44	3·76	4·06	1·96	1·48	1·65	2·56	2·91	3·03	·81	·81	1·03
	P-2	2·90	3·77	4·07	1·08	1·44	1·79	2·27	3·23	3·45	·68	·93	1·22
	P-1	2·87	3·97	4·47	1·01	1·22	1·87	2·26	3·23	3·32	·52	·90	1·16
	P-4	....	3·64	4·06	....	1·45	2·15	....	3·47	3·58	....	·87	1·27
Free nicotine	P-3	·96	·86	·87	·77	·58	·63	·69	·63	·55	·47	·24	·23
	P-2	·80	·74	·79	1·22	·54	·45	·78	·63	·60	·34	·31	·35
	P-1	·91	·98	·93	·62	·56	·53	·76	·75	·60	·41	·29	·35
	P-4	....	·89	·82	....	·71	·69	....	·75	·72	....	·39	·34
Total nitrogen	P-3	3·54	4·59	4·98	2·65	3·11	3·28	3·36	4·47	5·22	3·13	2·88	3·52
	P-2	2·94	4·17	4·80	2·15	2·79	2·94	3·02	4·46	5·19	2·23	2·88	3·50
	P-1	3·29	4·05	5·38	2·57	2·84	3·19	2·89	4·38	5·29	2·01	2·72	3·33
	P-4	....	4·17	4·76	....	2·77	3·16	....	3·75	4·82	....	2·61	3·21
Nitrate nitrogen	P-3	·64	·81	·68	1·64	1·38	1·26	·52	·35	·26	2·03	1·62	1·30
	P-2	·29	·60	·47	1·28	1·31	1·00	·90	·61	·62	2·04	2·11	1·72
	P-1	·48	·46	·63	1·80	1·46	1·08	·64	·45	·53	2·33	2·08	1·47
	P-4	....	·75	·52	....	2·05	1·07	....	·57	·60	....	2·16	1·45
Nicotine nitrogen	P-3	·60	·65	·70	·34	·26	·29	·45	·51	·52	·14	·14	·18
	P-2	·50	·65	·71	·20	·25	·31	·40	·56	·60	·12	·16	·21
	P-1	·50	·69	·77	·18	·22	·33	·40	·56	·60	·13	·16	·21
	P-4	....	·63	·71	....	·27	·38	....	·60	·62	....	·15	·23
Ammonia nitrogen	P-3	·52	·78	·71	·44	·77	·99	·02	·21	·45	·50	·79	·89
	P-2	·52	·71	·77	·40	·90	·54	·00	·15	·50	·14	·52	·75
	P-1	·52	·70	·82	·74	·77	1·06	·00	·28	·43	·35	·57	·83
	P-4	....	·68	·68	....	·68	·48	....	·32	·69	....	·48	·88

5. None of the other constituents show any consistent relation to phosphorus fertilization. The percentage of Mn_3O_4 remains very constant throughout.

The following conclusions can be drawn from table 4:—

1. The ash content of light-coloured leaves is consistently higher than that of dark leaves.

2. Light leaves contain more $Fe_2O_3 + Al_2O_3$, CaO, MgO, K_2O, Na_2O, nitrate nitrogen and possibly Cl than dark ones. This tendency in regard to K_2O was not observed in the former potash experiment.

3. Dark leaves contain more P_2O_5, nicotine, total nitrogen, and all nitrogen fractions except nitrates than light ones. This tendency for P_2O_5 is also different from that observed in the potash experiment.

4. S in this series failed to show any consistent relation to leaf colour. The percentages of Mn_3O_4 show very little variation of any kind. Figures for free nicotine do not indicate any significant differences.

The following conclusions can be drawn from table 5:—

1. The total ash content is much higher towards the bottom of the plant, and the variations are very large in this case.

2. In passing from the bottom of the plant to the top there is an increase in the percentages of P_2O_5, total nicotine, total nitrogen, ammonia nitrogen, and possibly S and Cl. The increases in S and Cl are rather doubtful, although there is a slight trend in some cases. The variation in P_2O_5 content according to leaf position on the plant is found to be even greater than the difference between two comparable samples taken from plots which have received treatments as widely different as 40 pounds of P_2O_5 per acre, and 320 pounds per acre.

3. In passing from the bottom of the plant to the top there is a decrease in the percentage of CaO, MgO, K_2O, and Mn_3O_4. This is the only significant difference observed for manganese.

4. $Fe_2O_3 + Al_2O_3$, Na_2O, and free nicotine show no consistent relation to leaf position.

The following general conclusions may also be drawn from a study of the foregoing tables. Many of the same general tendencies that were noticeable in the potash series have also been observed in the present "quantity-of-phosphorus" series. Potash and nitrate nitrogen percentages are usually about twice as high in the midrib as in the leaf tissue. The percentages of P_2O_5 are remarkably constant in view of the many different treatments and types of sampling. Total nicotine varies closely with the total nitrogen in the plant. Nitrate nitrogen is an extremely variable quantity.

The Calcium-Magnesium Ratio

The calcium-magnesium ratio is an important relation in the physiology of the tobacco plant (4, 6). It was observed previously that the rate of potash intake in the plant has apparently no effect on this ratio. Table 6 gives the figures of the ratio for the present series, as calculated from the percentages in table 3.

TABLE 6.—CALCIUM-MAGNESIUM RATIO

Treatment	Leaf			Midrib		
	1931	1932	Average	1931	1932	Average
P-3	4·61	4·50	4·56	3·30	3·94	3·67
P-2	5·11	5·18	5·15	3·65	3·92	3·79
P-1	4·90	5·29	5·10	3·66	4·17	3·92
P-4	4·74	5·51	5·13	3·71	4·13	3·92

These figures give some indication that the calcium-magnesium ratio tends to increase in direct proportion to increasing phosphorus application. The explanation of this tendency is found again in the fact that any increase in superphosphate application involves a corresponding increase in the amount of available calcium, and consequently in the amount of absorbed calcium.

Effect of Rainfall on Phosphorus Intake

It has been shown that there are apparently very few factors which influence the constant percentage of P_2O_5 in tobacco. The effect of rainfall on the intake of this element was also studied. The years 1931 and 1932 were excellent years for such a comparison since there was such a great difference in the rainfall for the two years. Table 7 gives the comparison of phosphorus content with rainfall in inches of rain between the dates June 1 and Sept. 10 which is approximately the length of time the plants were in the field.

TABLE 7.—COMPARISON OF PHOSPHORUS CONTENT WITH RAINFALL

Year	Rainfall in Inches	Percent P_2O_5							
		P-3		P-2		P-1		P-4	
		Leaf	Midrib	Leaf	Midrib	Leaf	Midrib	Leaf	Midrib
1931	4·78	·42	·40	·42	·44	·44	·54	·54	·67
1932	11·83	·40	·48	·56	·52	·54	·59	·54	·63

The above results are not altogether consistent although most of the comparisons show a greater phosphorus percentage in the wet year. A comparison of the phosphorus content of top leaves and midribs in table 5 also shows a greatly increased percentage of phosphorus in the 1932 samples. However, more data on the subject are required before any definite conclusions can be drawn.

The figures for CaO, MgO, and the calcium-magnesium ratio in tables 3 and 6 show that the ratio is higher in a wet year, and that there is always a relatively higher percentage of CaO and a lower percentage of MgO absorbed during a wet year. This confirms the results obtained with the potash series.

Burn Tests

Phosphorus as well as potassium has a decided effect on the combustion of tobacco, but it is a distinctly detrimental effect. It is generally agreed that an excess of phosphorus in the leaf causes it to burn sluggishly and shortens the time of burning. A number of samples of the 1930 crop from the "quantity-of-phosphorus" plots were tested for fire-holding capacity, and the results are given in table 8.

TABLE 8.—BURN TESTS—1930 CROP

Treatment	Duration of Burn (in seconds)
P-3	23·1
P-2	19·3
P-1	8·2
P-4	14·1

These figures confirm the general idea that an excess of phosphorus in tobacco or in the tobacco fertilizer is injurious to the fire-holding capacity, and the duration of burn is greatly reduced with successive application of phosphorus fertilizer.

Summary

1. In a five-year series of fertilizer experiments it is shown that phosphorus has a very decided effect on both the quality and yield of cigar tobacco. Both quality and yield are greatly enhanced by successive increasing applications of phosphorus fertilizer.
2. Chemical analysis of tobacco leaves from the phosphorus plots indicates that variations in phosphorus fertilization have very little effect on the phosphorus content of the leaf, although there is a slight increase in absorption. There is also an increase in Ca, S, and Cl, and a decrease in ash, $Fe_2O_3 + Al_2O_3$, K_2O, Na_2O and nitrogen.
3. Ash, $Fe_2O_3 + Al_2O_3$, CaO, MgO, K_2O, Na_2O, nitrate nitrogen, and Cl are more abundant in light-coloured leaves than in dark ones, while dark leaves contain more P_2O_5, nicotine, and nitrogen fractions.
4. Ash, P_2O_5, nicotine, nitrogen, ammonia, S, and Cl are more abundant in the upper parts of the plant, while CaO, MgO, K_2O, and Mn_3O_4 are found in greater quantities near the base of the plant.
5. The calcium-magnesium ratio increases with increasing phosphorus fertilization.
6. Tobacco absorbs more phosphorus during a wet season than during a dry season, and also a greater proportion of calcium than magnesium.
7. Phosphorus has a distinctly detrimental effect on the fire-holding capacity of tobacco.

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MINERAL ABSORPTION STUDIES WITH TOBACCO

Introduction

The fundamentals of plant nutrition constitute one of the less understood sections of plant physiology. It is recognized, of course, that minerals and other inorganic elements play a very important role in the economy of plant life, but a complete knowledge of the functions of any one of the elements is lacking as yet. On the other hand, contemporary scientific literature contains the accounts of many experiments in this field, but most of them have an immediate practical value rather than a fundamental significance. The present investigation is a study of the rates of growth and mineral absorption throughout the whole growing period in three types of commercial tobacco. Tobacco is a very sensitive and responsive plant, and admirably suited to this type of experiment. This work has as its aim not so much a study of the functions of the various elements or even a search for the absolute balance of nutrients required in fertilizer or soil, but rather an observation of the rates of absorption and a study of some of the factors affecting those rates, including the problem of translocation. There are many factors that affect the absorption of minerals by plants and among them are light, the concentration and availability of nutrients in the exterior medium, the reaction of the exterior medium, temperature, humidity, water supply. Hence the problem becomes exceedingly complex, and it is only natural to find that the results of one crop year are not duplicated by those of another. In this work only the so-called essential elements have been considered. With the possible exception of manganese, none of the trace elements have been studied.

Material and Methods

The present project was started during the summer of 1935 with cigar tobacco grown on the fertilizer plots of the Tobacco Division at the Central Experimental Farm, Ottawa. All plants were taken from a standard fertilizer plot which had received the equivalent of 4,000 pounds per acre of a 4-4-5 mixture, and all the normal cultural treatments. The variety of tobacco used was Comstock Spanish. The experiment was started at the beginning of the season at the time of transplanting and continued throughout the season until harvesting. Samples were selected at regular intervals so as to be representative of the various characteristic stages of plant growth. These stages were named as follows—seedling stage, early growth, mid-vegetative, early bud, early bloom, harvesting. Approximately 100 plants were required for a representative sample of the first stage, and 50 plants for the second stage. From the time of the third stage until the end of the experiment three average normal plants were used.

After the plants were selected at each stage, they were divided into the following portions—five bottom leaves, five middle leaves, five top leaves, tops, stalks. In the cases of the smaller plants in the early stages where there were insufficient leaves to carry out this separation completely, the portions were made up as far as the leaves would go beginning with the bottom leaves, and the portion designated tops was added only when the floral head began to appear. The individual portions were weighed, the tissue was brushed free of sand and soil, and then cut up with a knife into small fragments. A representative sample was taken from each portion for a moisture determination. The remainder was dried at a temperature of 80° to 90° C., ground to a fine powder, and stored for future analysis. In this paper the complete work of one year on one type of tobacco is termed one experiment.

Fig. 1.—Burley tobacco at progressive stages of growth.

1. Early growth stage.
2. Intermediate stage.
3. Mid-vegetative stage.
4. Late vegetative stage.

FIG 2.—Burley tobacco at progressive stages of growth.

5. Early bud stage.
6. Early bloom stage.
7. Late bloom stage.
8. Late bloom stage—topped plant.
9. Harvesting stage.
10. Harvesting stage—topped plant.

The 1935 experiment was repeated in 1936 with a few modifications and additions. It was found that in 1935 there were certain critical periods of change that were not represented in the six stages mentioned above, and so three extra stages or times of sampling were added; the list was then as follows—seedling stage, early growth, intermediate, mid-vegetative, late vegetative, early bud, early bloom, late bloom, harvesting. In addition, the experiment was extended to include an observation of the cultural practice of topping which is carried out at the early bloom stage. From this stage until the end of the experiment comparable samples of topped and untopped plants were selected at each stage. In 1937 the experiment was again repeated and further minor additions were made. Observations were recorded on the height of the plant and the number of leaves at each stage. Furthermore, the variety of tobacco being used in the experiment was changed from Comstock Spanish to Resistant Havana 211.

In 1936 the project was expanded to include a corresponding experiment with flue-cured tobacco. These plants were grown on the fertilizer plots of the Tobacco Substation at Delhi, Ontario. As with the cigar tobacco, they were taken from a standard plot which received 1,000 pounds per acre of a 2-10-8 mixture and all the normal cultural treatments. The variety used was White Mammoth. Since the accepted method of harvesting flue-cured tobacco is the priming method, the leaves in this experiment were divided into the various primings rather than into the arbitrary portions used with cigar tobacco. Only seven stages were sampled in this experiment, but when it was repeated in 1937 there were nine stages as in the cigar experiment. Pictures of the flue-cured tobacco at each stage were taken both years. No observation was made in either year of the effect of topping in flue-cured tobacco.

In 1940 the experiment with flue-cured tobacco was again repeated. In this series the effect of priming upon subsequent mineral absorption was studied. For this purpose it was necessary to take samples at three stages of harvesting—(1) harvesting stage at the time of first priming, (2) harvesting stage at the time of second priming, (3) harvesting stage at the time of third priming. At each of these stages both primed and unprimed plants were sampled and in this way a comparison was obtained at each stage between leaves on an unprimed plant and remaining leaves on a primed plant. In order to carry out this type of an experiment it was necessary to top all plants at the early bloom stage, and after that time no untopped plants were sampled. This is a departure from the procedure with the two previous flue-cured tobacco experiments, and the differences will be noted in the tables. One further change was the addition of total nitrogen to the list of constituents in the analysis. In this connection it should be stated that the nitrogen analysis was made on the same dried sample which was used for mineral analysis. Preliminary tests indicated that there was no significant difference in nitrogen content between the dried sample and the fresh green material.

In 1940 the project was again expanded, this time to include an experiment on a third type of tobacco, burley. These plants were grown on the fertilizer plots of the Experimental Station at Harrow, Ontario. They were grown on a standard plot receiving 1,000 pounds per acre of a 4-8-10 mixture and all the normal cultural treatments. The variety used was Harrow Velvet. Pictures were taken of the various stages of growth. (Figures 1 and 2.)

The details of this experiment were the same as those of the 1936 experiment with cigar tobacco, including the comparison between topped and untopped plants. Here again total nitrogen was included in the list of constituents analysed.

All the chemical determinations were made according to the official methods of the A.O.A.C. (1935).

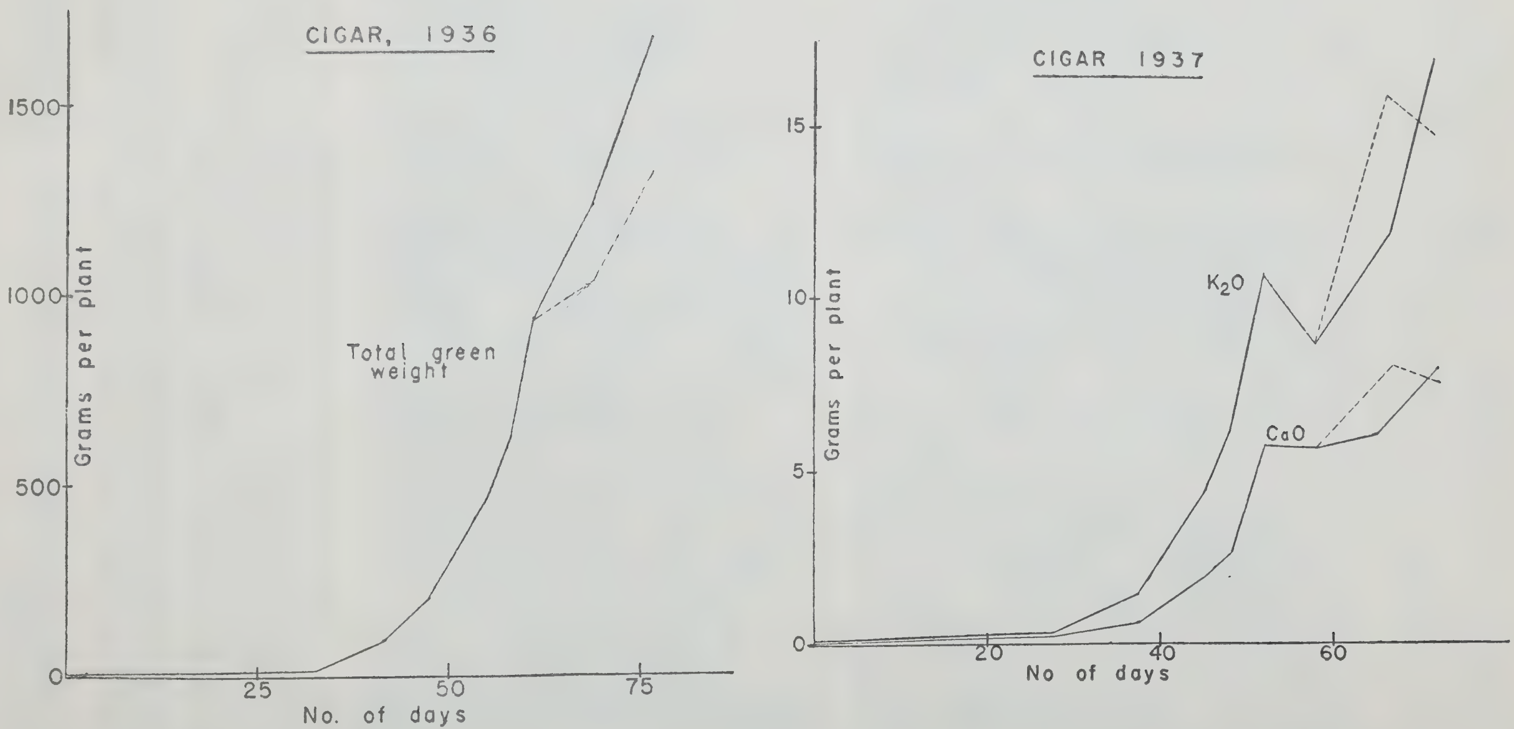
CIGAR, 1936
Grams per plant
1500
1000
500
0
Total green weight
25
50
75
No. of days
CIGAR 1937
Grams per plant
15
10
5
0
K2O
CaO
20
40
60
No of days

FIG. 3

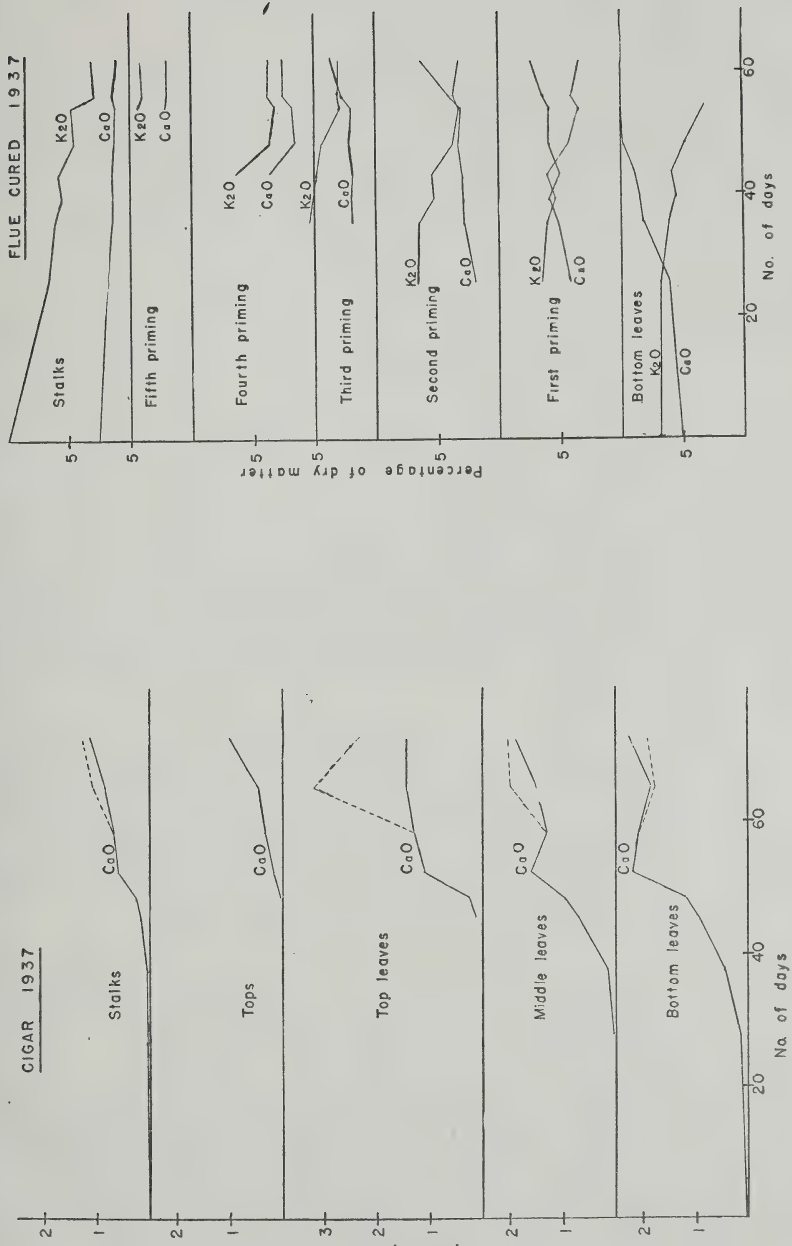
FLUE CURED 1937
Stalks
Fifth priming
Fourth priming
Third priming
Second priming
First priming
Bottom leaves
K2O
CaO
Percentage of dry matter
No. of days
CIGAR 1937
Stalks
Tops
Top leaves
Middle leaves
Bottom leaves
Grams per plant
No. of days

FIG. 4

Results

One of the main difficulties of these experiments was the selection of comparable samples. In the presentation of the following results it will be quite evident that in a few cases the samples taken were not truly representative—in other words they were not average normal plants for the standard treatment under consideration. This was evident only after analysis, since the plants appeared comparable in the field. There was also some trouble with sand sticking to the leaves. Most of the sand was removed with a stiff brush, but in some cases it remained on the sample and interfered with the iron determination. In order to avoid this difficulty a determination of insoluble residue was made on every sample. There was distinct evidence to show that this quantity was roughly equivalent to the extraneous sand on the leaves. Therefore, in calculating the analysis percentages to the customary dry-matter basis the figures for all determinations were brought to what has been termed a "moisture-free, sand-free basis." In addition, in the determination of ash the insoluble residue percentage was subtracted from the ash percentage. From this original expression of results as percentage of dry-matter three further calculations were made—(1) percentage of green matter, (2) percentage of ash, (3) a calculation giving the absolute weight in grams per plant of each constituent in every sample. This last is known as the biometric method of expression in contrast to the percentage method. Such a calculation was possible since the weight of each portion was recorded at every sampling as well as the number of plants in the sample. Using this absolute-weight calculation the amounts of each constituent in all the plant portions were added together thus giving the total quantity of each mineral constituent in one average individual plant at every stage of growth. And finally, one step farther, using the average figures of 8,640 cigar plants per acre and 6,800 plants for flue-cured tobacco and 6,400 burley plants, a calculation was made giving the number of pounds of each constituent absorbed during the season by an acre of tobacco.

The results of the whole project have been assembled each year in tabular form according to this plan. In addition the figures representing percentage of dry weight and the absolute weight per plant in grams in each plant part and the total plant have been reduced to graphical form. From a study of the tables and the graphs certain conclusions have been arrived at concerning the ontogenetic drifts of the various mineral elements in each experiment. Complete tables of results and calculations will be found in Appendix 1. In addition, certain representative graphs are also given in Figures 3 and 4.

On the preliminary examination of results from the various experiments it was evident that one year's results could not be duplicated the following year and that some variable factor or combination of factors caused an appreciable fluctuation in mineral absorption from year to year. With this in mind a study was made of the rainfall during each crop season. Tables of the daily rainfall at Ottawa, Delhi and Harrow for the respective periods are presented in table 1, and these data explain to a certain extent the fluctuations in mineral absorption. The years 1937 and 1940 were normal in both Delhi and Ottawa with adequate supplies of moisture well distributed. In Ottawa, 1935 was a fairly good year but most of the rainfall came early. The year 1936 was dry in both Ottawa and Delhi, but particularly in Delhi where conditions were very bad. These conditions are reflected directly in the yield and quality of the tobacco produced as well as in the plant growth curves and the mineral absorption. The year 1940 in Harrow was a very wet year. Excessive rainfall early in the season prevented the plants from making a good early start.

TABLE 1.—RAINFALL—INCHES OF RAIN

—	Ottawa			Delhi			Harrow
	1935	1936	1937	1936	1937	1940	1940
June 1		·02		·83			
2		·65	·26		·25		·05
3	·02	·20	·11				
4	·37						
5					·16		
6				·45			·60
7	·74	·02					·11
8					·16		
9			·04		·44		·42
10			·02				
11		·10	·36				1·14
12		·45	·11			·04	·07
13					·59		
14	·66		·03		·05		
15	1·17						
16					·04		
17	·73	·09	1·16	·42	·58		
18		·13	·48		·51	1·44	·99
19	·48						·02
20	·34		·30		·30	·03	
21	·08		·31		·36		
22	1·01						·08
23	·20					2·61	·23
24						·36	1·44
25						·16	·09
26		·26		·36	·24	·62	·13
27	·20		·12	·08			
28		·06	·06		·03	·32	·26
29		·04	·02	·25			·02
30			·26			·04	·13
Total	6·00	2·02	3·64	2·39	3·71	5·62	5·79
July 1							·01
2			·08		1·96		
3		·59				·03	
4		·14			·04		·01
5		·03					
6							
7	·16						
8						·07	·22
9	·80	·58	·59		·04		·02
10	·25	·96	·02		·30	·01	·01
11		·03	·18		·32	·19	·36
12	·37			·09			·01
13	·19	·66					
14			·02		·70		
15	·49		1·42		·13	·42	1·39
16	·03		·14				·24
17			·75				
18							
19	·33	·02					
20						·10	
21	·30					·02	
22	·15			·07			
23	·05	·08		·06			·02
24		·71			·05		
25		·28	·47		·36		·22
26			·22	·30		·35	·03
27			·05			·04	1·44
28	·08		·02		·07		
29	·08	·19					
30	·02		·02			·05	
31	·08		·01				
Total	3·28	4·27	3·99	·52	3·97	1·28	3·96
Aug. 1			·02				
2							
3			·01				
4			·02				1·13
5	·32					·12	·55
6					·07	·71	1·14

TABLE 1.—RAINFALL—INCHES OF RAIN—*Continued*

—	Ottawa			Delhi			Harrow
	1935	1936	1937	1936	1937	1940	1940
7	....	....	·02	....	·01	....	....
8	....	....	·05	....	1·07	....	....
9	....	....	·04	....	1·25	....	....
10	....	....	·95	....	·49	....	....
11	·06	....	·37	....	....	....	....
12	....	....	·26	....	·33	·09	....
13	·06	....	·02	....	....	·53	....
14	....	....	....	·01	....	....	....
15	....	1·46	....	....	....	....	....
16	....	....	·05	....	....	....	....
17	....	·07	....	....	·32	....	....
18	....	....	....	....	....	·36	·13
19	....	....	1·49	·85	....	....	·04
20	·32	....	....	·05	....	....	....
21	·22	·20	....	·10	....	....	·21
22	....	....	·22	·16	....	·03	....
23	....	·28	....	·02	....	....	....
24	....	....	....	....	....	....	....
25	....	....	....	·07	....	·28	·43
26	....	....	....	....	....	·09	·32
27	·06	....	....	....	....	·31	·61
28	·04	....	....	·17	....	....	....
29	....	·72	....	....	....	·66	·11
30	·09	·07	....	....	....	·67	·49
31	·01	·17	....	....	....	....	....
Total	1·18	2·97	3·52	1·43	3·54	3·85	5·16
Three months total	10·46	9·26	11·15	4·34	11·22	10·75	14·91

For purposes of comparison, the yield and grade index figures for the tobacco used in each experiment are presented in table 2.

TABLE 2.—CROP DATA

Type of Tobacco	Year	Yield	Grade Index
Cigar	1935	1,965	22·8
	1936	1,748	19·4
	1937	2,110	24·7
Flue-cured	1936	813	23·0
	1937	1,494	37·1
	1940	1,088	24·0
Burley	1940	1,127	11·2

As mentioned previously, certain additional information on the height of the plant and the number of leaves was recorded in the two 1937 experiments. These figures are presented in table 3 together with the total weights of the plants at each stage of growth.

The observations of each individual constituent will now be dealt with separately in detail. In setting up these conclusions an effort has been made to point out general or universal trends as far as possible, and to disregard any deviations that may be due to sampling error, unusual weather conditions, or other temporary factors. It is perfectly obvious that the collection of such a large quantity of data from experiments which are to a certain extent uncontrolled, must contain some results that do not fall into line with the general conclusions. Certain distinctions, of course, between the various types of

TABLE 3.—PLANT MEASUREMENTS

Stage	Date	Number of days of growth	Height (ins.)	Number of leaves	Weight (gms.)
	Delhi—1937				
Seeding	June 3	....	2·00	4	3·3
Early growth	June 29	26	2·50	8	36·4
Intermediate	July 9	36	8·75	13	177·5
Mid-vegetative	July 13	40	14·25	14	360·3
Late vegetative	July 17	44	20·50	17	537·6
Early bud	July 22	49	37·00	18	493·6
Early bloom	July 28	55	45·00	20	847·2
Late bloom	July 30	57	57·00	20	1,156·2
Harvesting	August 5	63	65·00	21	1,039·2
	Ottawa—1937				
Seeding	June 14	....	4·0	6	5·1
Early growth	July 12	28	4·5	7	34·7
Intermediate	July 22	38	7·0	10	137·2
Mid-vegetative	July 30	46	17·0	14	505·2
Late vegetative	August 2	49	27·0	16	769·3
Early bud	August 6	53	41·0	20	1,250·4
Early bloom	August 12	59	56·0	22	1,365·9
Late bloom	August 19	66	69·0	21	1,531·2
Harvesting	August 26	73	72·0	22	2,094·8
Late bloom (topped)	August 19	66	35·0	17	1,968·2
Harvesting (topped)	August 26	73	30·0	16	1,757·5

tobacco under consideration have been indicated, but the main purpose has been to find progressive changes common to all under the normal conditions of ordinary field practice, and changes which are duplicated each year. The conclusions have been arrived at from a study of the graphical representation of the figures in Appendix 1, but limitations of space prohibit the presentation of more than a few representative graphs here.

Total Green Weight.—The growth curves for each experiment demonstrate a normal regular progression throughout the period of seasonal growth. Following transplanting at the seedling stage growth is very slow for some time. Then the plant becomes well established about the mid-vegetative stage, and thereafter the rate of growth increases considerably, becoming very rapid during the budding and blossoming period, and finally slowing up towards the harvesting stage. This progression has been duplicated several times; it is quite characteristic of plant growth in general, and will be considered as the normal drift throughout the remainder of this discussion. The growth curve for the bottom leaves tends to level off earlier than that for the whole plant, and in flue-cured tobacco there is even a decrease in the green weight of the bottom leaves and first primings towards the end of the season. The upper leaves have a normal growth curve, but the stalks have an increasing growth rate throughout the whole season with a very rapid jump in rate just before harvesting. The effect of topping is to cut down the weight of the whole plant. The weight of the bottom leaves and stalks decreases, but the middle leaves show a slight increase and the top leaves a very definite increase in weight due to topping.

Dry Weight.—The dry matter in the tobacco plant has much the same ontogenetic trend as the green matter except that there is not the same decrease in rate of growth at the end of the season. The rapid rate of mid-season growth continues through harvesting. As above, however, there is more slowing up of growth in the bottom leaves than in the higher parts of the plant especially in flue-cured tobacco. The stalks exhibit a sharp rise in growth rate at the end of the season. The top of the plant contains a higher percentage of dry matter

than the bottom portions. These percentages tend to remain fairly constant in the leaves throughout the season but the percentage in the stalks rises steadily from the beginning until it is three times the amount at harvesting. By the end of the season the stalks are heavy, dense, and woody. The effect of topping on the content of dry matter is practically the same as on the green matter.

Ash.—The constituent designated as ash represents roughly the total mineral content of the plant. The drift here is practically the same as the green matter drift. Topping causes a decrease in the total amount of ash in the plant. There is a distinct levelling in the graph of the ash quantities in the bottom leaves towards the end of growth, but a continuous rise in the upper plant parts and the stalks all through growth. The percentages, on the other hand, increase throughout the season in the bottom leaves, remain fairly constant in the middle leaves, show a slight decrease in the top leaves, and a very definite descending gradient in the stalks. In fact the percentage in the stalks falls to about half its original value in every case. Topping causes a slight decrease of ash in the bottom leaves and a very small increase in the top leaves. There is a decrease in the stalks and a decrease in the whole plant.

Calcium.—The absorption curves for calcium are very regular, with the characteristic levelling at the end. The curves for bottom leaves level off quite early in the season, but the top leaves continue their absorption until harvesting. The curves for the stalks also have a slight levelling. The stalks contain only about half as much calcium as the bottom leaves. Topping causes a small decrease in the amount of calcium in the bottom leaves but a large increase in the middle and top leaves and in the stalks. The percentage of calcium in the bottom leaves increases during the first part of the season but remains constant thereafter. It increases also in the middle and top leaves, but remains constant in the tops. The percentage in the stalks falls steadily throughout the season.

Potassium.—In a year of normal rainfall a cigar tobacco plant usually contains twice as much potassium as calcium. In flue-cured tobacco the amounts are fairly equal at all times, with probably a little more potassium. In a year of excessive moisture the amount of potassium absorbed will probably fall below the calcium absorption on account of leaching. This was the case in the 1940 burley experiment. The absorption curve for potassium does not level off at the end, but rather indicates a sharp rise in absorption just prior to harvesting. Otherwise it follows the normal course. Here again the curve for the bottom leaves levels off about mid-season while the top leaves and stalks continue to absorb potassium until the last stage of growth. The effects of topping are not consistent but the probable trend is an increase in the amount of potassium due to topping. The figures for percentage are quite erratic, probably on account of the relative mobility of this element. However, there is an interesting distinction here between types of tobacco under consideration. In flue-cured tobacco and burley there is a definite decreasing drift in percentage through the season in all portions of the plant and particularly in the stalks. In cigar tobacco, on the other hand, the percentage increases throughout the season in the bottom, middle, and top leaves, remains fairly constant in the tops, but the stalks as with flue-cured tobacco have a decreasing gradient. The effects of topping are inconsistent except in the stalks where there is a slight fall in percentage of potassium in topped plants. In cigar tobacco the stalk has twice as high a percentage of potassium as the bottom leaves; in flue-cured tobacco and burley there is about the same in both portions. There is some evidence of antagonism between potassium and calcium in the bottom leaves.

Magnesium.—Again a curve of the general form is found but this time with a definite levelling off after mid-season indicating that there is very little absorption of magnesium after that time. Again also the levelling is more pronounced in the bottom and middle leaves with a slight decrease in certain

cases. Topping causes a slight decrease in the amount of magnesium in the bottom leaves, an increase in the middle and top leaves, and a very large increase in the stalks. The percentages of magnesium show surprisingly little variation. The general effect is for a slight decrease in the leaves throughout the season and a more definite decrease in the stalks. In flue-cured tobacco, however, the percentage increases in the bottom leaves. The only definite effect of topping is to cause a rise in the percentage of magnesium in the stalks.

Phosphorus.—The absorption of phosphorus by tobacco is relatively slow throughout the season with a slight levelling of the absorption curve about mid-season. This is followed, however, by an enormous increase at the very end of the growing period. Absorption is fairly slow and steady in all plant portions through the first stages of growth, and then all parts of the plant benefit by the rapid uptake of phosphorus just previous to harvesting—the bottom parts least of all, but the top portions and stalks very strongly. The tops and stalks multiply their content of phosphorus by three or four or more during the last week of growth. It is quite evident that this element is being taken up for the production of flowers and seeds; and even although the plant is topped the power of absorption seems to be greatly increased. The percentage of phosphorus in all plant parts has a definite decreasing gradient throughout the season except in some cases where the rapid absorption at the end of growth is reflected in increasing percentages in the tops. The reason for this apparent contradiction is that all the new phosphorus absorbed in the last week of growth immediately becomes concentrated in the tops which may have up to three times as much phosphorus as the bottom leaves. In almost all cases topping causes an increase in the amount and the percentage of phosphorus. A probable exception is the bottom leaves where the effect is negligible. There is some evidence of antagonism between phosphorus and magnesium.

Sulphur.—This element has a fairly regular absorption curve with a slight rise at the end of growth corresponding to that for phosphorus. The bottom and middle leaves show a decrease in sulphur content at the end of the season, but the top leaves, tops, and stalks have the characteristic upward turn. The topping results are somewhat inconsistent but the general effect is probably a decrease in the stalks and lower leaves and a slight increase in the upper leaves. With regard to sulphur percentages, the flue-cured seedling starts out with a fairly high percentage but this rapidly falls to a much lower value and thereafter remains constant in all plant parts. The stalks probably decrease slightly in percentage of sulphur throughout the season, but in general the percentages are surprisingly stable.

Chlorine.—The absorption curves for chlorine have the same general trends as those for sulphur except for a few rough places. After mid-season, however, there is a very definite cessation in the absorption of chlorine. From this point on, the amount of chlorine either remains constant or decreases. In all cases the amount in the bottom leaves declines and that in the top leaves remains constant or increases very slightly. This cessation occurs just previous to the rapid absorption of phosphorus. Topping causes an increase of chlorine in all plant parts with the probable exception of the bottom leaves where there is a slight decrease. The percentage of chlorine decreases in all plant parts with age but tends to remain more constant in the tops. Cigar seedlings always contain a large percentage of chlorine—about two to three times the normal amount. This percentage drops off immediately, however, to a normal value and thereafter there is a gradually declining drift. Flue-cured and burley seedlings are more normal in this respect although as mentioned above they contain a high percentage of sulphur. Topping causes an increase in percentage of chlorine in all plant parts.

Iron.—The results of iron analysis in these experiments are very erratic on account of interference from sand adhering to the samples. However, certain general trends have been traced. There appears to be a rapid rise in absorption rate at the end of the season. The curve for the bottom leaves levels off, but those for tops and stalks rise steadily until harvesting. The results of topping are very uncertain except for a definite increase of iron in the stalks. The percentage of iron decreases throughout the season—most noticeably in the bottom leaves and stalks. The tops tend to maintain a constant percentage.

Any determinations of aluminium in these experiments were made by difference and the results given are not wholly reliable. For this reason it has been impossible to determine any general trends in the absorption of this element, although all figures for analysis may be found in the tables in Appendix 1.

Manganese.—This element is found in tobacco in very minute quantities. It exhibits a normal absorption curve except that there is a sharp increase in the rate at the end of growth as is the case with phosphorus. This is more noticeable in a wet season. The absorption curve for the bottom leaves and the stalks tends to level off near the end of growth but the sharp increase is seen in the tops. Topping causes a decrease in the amount of manganese in the bottom leaves, an increase in the top leaves, and practically no change in the stalks. The percentage of manganese declines with age in the stalks, increases in the bottoms, and remains fairly steady in the upper parts of the plant except for the final rise at the end.

Nitrogen.—The analysis for total nitrogen was only introduced in the 1940 series of experiments and the data are not complete, but the general trends observed are very definite. Absorption of nitrogen increases steadily throughout the whole season in all plant parts, but the percentage has a very regular decline in all parts. Nitrogen is always concentrated in the more rapidly growing sections and appears to be translocated there from the older parts of the plant, particularly in flue-cured tobacco which is given a restricted nitrogen diet. The effect of topping is a decided increase in the amount but not in the percentage of nitrogen in the leaves.

The Priming Investigation.—The effect of priming is that it causes a very definite increase in weight and absorption in all the remaining leaves on the plant, but a decided decrease in weight and in the amount of all constituents in the stalk. This seems to indicate that there is very distinct evidence of translocation from stalk to leaves after priming has started. The same trend may be found in all constituents under consideration. Concerning percentages, however, the percentages of K_2O and MgO in the remaining leaves on the primed plant are slightly lower than in those on the unprimed plant.

TABLE 4.—MINERAL ABSORPTION PER ACRE (POUNDS)

Constituent	Cigar Tobacco			Flue-cured Tobacco			Burley
	1935	1936	1937	1936	1937	1940	1940
Total green weight....	26,356·7	23,626·6	33,476·0	8,270·5	15,578·0	9,668·8	26,120·8
Moisture..............	23,475·3	20,740·3	29,358·0	6,756·6	12,954·7	7,732·2	22,827·6
Dry matter...........	2,881·4	2,886·3	4·118·0	1,513·6	2,622·2	1,936·6	3,293·9
Ash..................	569·2	537·2	723·4	....	278·8	223·5	486·2
Fe_2O_3..............	10·6	1·7	3·1	2·1	2·1	·5	1·4
CaO..................	97·3	126·9	144·7	41·9	92·9	79·4	164·0
MgO..................	23·3	15·5	28·1	9·8	12·7	13·1	29·9
P_2O_5................	13·6	12·6	53·0	7·8	31·6	10·8	16·1
K_2O................	241·0	182·8	283·7	47·8	89·7	32·9	53·8
S....................	20·9	17·8	27·3	6·6	15·6	9·8	18·7
Cl...................	9·7	9·7	17·6	....	16·3	4·3	22·9
Mn_3O_4..............	·2	·6	4·6	·3	·3	·3	2·8

Mineral Absorption per Acre.—As mentioned previously, an approximation of the amount of fertilizer used by a crop of tobacco was obtained by calculating the mineral absorption per acre on the basis of figures obtained in these experiments. These figures have been assembled and are presented in table 4.

In the case of potassium almost all of this element supplied in the fertilizer is taken up by the crop. With phosphorus only a small percentage of the amount supplied is absorbed. Calcium is required in fairly large quantities, but the other elements in relatively small amounts. The amount of manganese absorbed is practically negligible, but seems to be quite sufficient to meet the plant needs.

Discussion

A great deal of work has been reported on plant growth and mineral absorption in plants. Miller (3) gives a comprehensive review of the literature dealing with theories in regard to plant growth, and the functions of individual minerals. Tottingham (8) discusses the "feeding power" of plants, treating each element individually. Considerable work of this nature has been done with corn, tomatoes, and some grain crops, but the work on tobacco has been somewhat restricted—E. H. Jenkins (2) published some of the first work on the mineral content of tobacco but his experiment was not a seasonal one. Roumanian investigators have published results on a mineral absorption experiment with tobacco but their work was done on small plants during the early stages of growth only. Morgan and Street (4) have reported on nitrogen assimilation in Havana seed tobacco. Vickery (9) has also investigated nitrogen metabolism. Various other workers have studied the trends of single elements. Petrie (7) made a thorough investigation of the ontogenetic drifts of potassium and calcium.

In the present paper the growth curves for tobacco exhibit normal average progressions with the exception that the period of senescence is not examined. These curves correspond closely to the respective yield and grade index results which in turn fluctuate in a most sensitive manner according to seasonal conditions. In seasons of adequate rainfall the curves reach their highest peak, and in dry seasons they are appreciably restricted. The same is true of every element studied in this project. One of the characteristic features of this absorption study is the apparent slowing up of physiological activity in the bottom portions of the plant after the bottom leaves have matured; in some cases there is even a decrease in the quantity and percentage of some constituents in these leaves. At the same time, the percentages are increasing in the upper plant portions at a more rapid rate than the constituents are being supplied to the whole plant. The logical conclusion is, therefore, that translocation of minerals is taking place in the plant in an upward direction. This phenomenon is more evident in flue-cured tobacco which is grown on a lighter soil with a lighter application of fertilizer than cigar tobacco. The plant in this case has a smaller initial supply of nutrients and, therefore, a greater need for translocation and reutilization of those already absorbed.

The ontogenetic drift of each element seems to assume a characteristic form. Thus certain elements such as sulphur, magnesium, and chlorine are absorbed in larger quantities at the beginning of the growing period, while others such as phosphorus and manganese are absorbed rapidly towards the end of the season. These drifts, which may be influenced by relative availability in the soil, are, however, partially independent of environment, and may be interrelated with the continuous changes in the rates of metabolism and growth which occur simultaneously. Thus the unusual absorption curve for phosphorus for example is probably the result of selective absorption.

The project as presented in this paper does not pretend to be an exhaustive study of the subject. Many additional phases still await investigation.

Summary

This paper is the account of a project which has been in operation for several years for the determination of the progressive absorption of minerals throughout the growing season by three types of commercial tobacco. Samples for analysis were selected at characteristic stages throughout the growth period from standard fertilizer plots on which the plants received all the normal cultural treatments. Tables and graphs are presented which show the ontogenetic trends in mineral metabolism of the various parts of the tobacco plant. The effect of the practices of topping and priming upon subsequent absorption is discussed, and an estimation of the amount of mineral intake per acre is given.

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PART II—CARBOHYDRATE INVESTIGATION

CARBOHYDRATES IN FLUE-CURED TOBACCO

Introduction

During the past fifteen years, the production of tobacco in Canada has grown from a very modest industry to one of large proportions, and production figures have increased tremendously. Throughout this period the bright Virginia flue-cured type has become increasingly important and its production has been multiplied nine times, with the result that it is now the most important type grown in Canada. Furthermore the quality of Canadian flue-cured tobacco has experienced a continued gradual improvement. With this background the present study was undertaken in order to investigate and if possible clarify some of the more fundamental physiological changes connected with the various cultural practices employed in the raising of flue-cured tobacco, and with the ultimate aim of bringing about still further improvements in quality. The first physiological group to be studied was the carbohydrates.

The literature on photosynthesis and the carbohydrate metabolism in plants is very extensive, and there are numerous references to tobacco. However, comparatively little work has been done with the bright Virginia flue-cured type, which possesses distinct physiological characteristics not found in such air-cured types as cigar leaf, or burley. The most recent work has been done by Darkis, et al. (3, 4) who has made an extensive study of flue-cured tobacco dealing with weather conditions and the effects of limed soils. He states that a low sugar content is associated with immature tobacco of poor quality, and that liming in general tends to lower the quality. He also gives an account of the distribution of various constituents in the tobacco plant. Garner in an early bulletin (9) mentions the transformation of starchy matter during the flue-curing process, but offers no supporting data. Beyond these it is difficult to find any detailed work on the physiology of flue-cured tobacco.

Analytical Methods

The methods for the determination of carbohydrates in plant tissue are many and varied, but after a complete survey of all the available literature, the following procedure was evolved:—

(*a*) *Determination of Sugars.*—When green tissue was used the sample was taken from the field on a bright sunny day if at all possible, at 11.00 a.m. It was taken immediately to the laboratory where the required leaves were brushed to free them from any adhering sand, and cut up into small pieces with a sharp knife. After thorough mixing, a 50-g. sample was weighed out for a moisture determination, and a second 50-g. sample for sugar determination was immediately plunged into 300 cc. of boiling 95 per cent ethyl alcohol, to kill the leaf and stop all enzyme action. Boiling was continued for 8 minutes, and the sample was then set aside until the following morning. The alcohol was then drained off and reserved. The tissue was placed in a large soxhlet extractor and extracted for 16 hours with 95 per cent alcohol. When cured or dried tissue was used the first extraction was omitted and a 10-g. sample was placed directly in the soxhlet tube in an extraction thimble and extracted for 16 hours. The total alcohol extract in

either case was then subjected to a vacuum distillation until all the alcohol was driven off. The residue was washed into a 500-cc. volumetric flask with water, 20 cc. of saturated neutral lead acetate was added, the solution was made up to volume, shaken, and filtered. It was then deleaded with solid Na_2HPO_4. Reducing sugars were then determined on the solution by the titration method of Lane and Eyon (19, 20) using methylene blue as an internal indicator. For solutions of very low sugar concentration, the reducing sugars were determined by the sodium thiosulphate volumetric modification of the official Munson and Walker method (26).

Three methods were tried for the separation of glucose and fructose in the reducing sugar fraction—(1) The modified Nyns's method of Jackson and Mathews (19) using Ost's solution. (2) A titration of aldose sugars with the standard iodine and alkali of Kline and Acree (17). (3) The hypoiodite method (38). The first was found to be most expeditious and satisfactory although involving a long calculation, and all figures given for glucose and fructose were obtained by this method.

Sucrose and total sugars were determined after inversion. A 100-cc. sample of cleared extract was boiled with 10-g. of citric acid for 12 minutes. The solution was cooled, neutralized with saturated NaOH solution, adjusted to correct volume, and reducing sugars determined as above.

(b) *Determination of Dextrin.*—The residue from the soxhlet extraction was again extracted with 500 cc. of cold water in a large flask for 24 hours with frequent shaking (39). The solution was filtered, washed, and the filtrate evaporated to a volume of 100 cc. Ten cc. of concentrated HCl was added and the solution refluxed for 2 hours. It was then cooled, neutralized with saturated NaOH, cleared with lead acetate, and reducing sugars determined as above.

(c) *Determination of Starch.*—The residue from the dextrin extraction was dried, weighed, then ground to a fine powder and stored, if necessary. A 2-g. portion was weighed out and allowed to soak for 18 hours in 100 cc. of 1 per cent potassium oxalate with frequent shaking. This treatment causes a chemical breakdown of the cell walls thus freeing the starch granules from the cells where they are stored. The solution was then filtered and washed. The residue was transferred into a small mortar with 10 cc. of water, some fine sand or pumice was added, and the tissue was triturated to a pulp. The mixture was then transferred quantitatively to a beaker with 90 cc. of water and heated in a boiling water bath for 30 minutes to gelatinize the starch. The solution was cooled to room temperature and the starch was hydrolysed with 10 cc. of 1 per cent solution of dialysed taka-diastase in a 48-hour incubation, using a few cc. of toluene to prevent development of moulds (31). Reducing sugars were then determined in the same manner as above.

(d) *Determination of Hemicellulose.*—The pulpy residue from the starch determination was refluxed for 45 minutes with $2\frac{1}{2}$ per cent sulphuric acid. The solution was filtered and neutralized with saturated NaOH. Clearing of the solution was not necessary since all other interfering reducing substances had been removed by previous extractions. The solution was made up to 200 cc. and reducing sugars determined as above. The fraction known as hemicellulose was calculated as dextrose.

Relation of Carbohydrates to Quality

The first step in this investigation was an attempt to discover what relationship exists between the various carbohydrate fractions and the quality evaluation of flue-cured tobacco. For this purpose two series of samples were obtained for analysis. The first series consisted of five samples all grown near Leamington, Ont., in 1934 and ranging from a very poor grade of leaf to the very best flue-cured tobacco as judged by the buyers, standards of texture, body, elasticity, colour and aroma. An estimated relative value in terms of cents per pound on the current market was also obtained for each sample. A second series of six samples of flue-cured tobacco grown in Eastern Carolina was also obtained which was comparable to the Canadian series in every respect. The results of the carbohydrate analysis of these two series are presented in the following tables 1 and 2.

TABLE 1.—CARBOHYDRATE FRACTIONS IN VARIOUS GRADES OF CANADIAN FLUE-CURED TOBACCO

Description of Leaf-grade	Value cts./lb.	Reducing sugars	Sucrose	Total sugars	Dextrin	Starch	Total carbohydrates
Fancy cigarette leaf..........	45	17·86	10·28	28·14	1·57	·95	30·66
Light green cigarette leaf.....	40	18·76	9·30	28·06	2·48	·59	31·13
Bright sponged leaf..........	28	20·58	3·43	24·01	1·25	·28	25·54
Heavy dark sponged leaf....	10	16·22	4·75	20·97	3·04	·43	24·34
Heavy bodied green.........	8	15·77	6·25	22·02	1·81	1·97	25·80

TABLE 2.—CARBOHYDRATE FRACTIONS IN VARIOUS GRADES OF AMERICAN FLUE-CURED TOBACCO

Leaf-grade Designation	Value cts./lb.	Reducing sugars	Sucrose	Total sugars	Dextrin	Starch	Total carbohydrates
C-1.........................	40	19·68	3·52	23·18	1·62	1·04	25·84
G-1.........................	35	15·43	5·50	20·93	1·39	·82	23·14
O-2.........................	25	13·21	1·44	14·65	1·10	....	15·75
R-3.........................	18	9·44	1·04	10·48	1·99	....	12·47
G-4.........................	10	8·38	1·13	9·51	1·19	·03	10·75
O-4.........................	8	5·87	·56	6·43	2·21	·07	8·71

It will be seen that with certain exceptions the general trend of these figures indicates that quality in flue-cured tobacco is directly related to the amount of carbohyrate in the leaf. The high grades contain a definitely higher percentage of reducing sugars, sucrose, total sugars, and total carbohydrates than do the lower grades. Starch and dextrin, however, are present in only relatively small quantities which do not appear to bear any consistent relationship to the leaf grades.

Based on these figures the content of total soluble sugars of flue-cured tobacco constitutes a relative measure of quality. This, of course, is not the only indication of quality, but it appears as though high-quality flue-cured tobacco must contain a fairly high percentage of soluble sugars. It is upon this hypothesis that all of the subsequent carbohydrate work with flue-cured tobacco has been based.

Flue-curing of Tobacco

Having determined the role of carbohydrates in the quality evaluation of flue-cured tobacco, the next step was to investigate the changes which occur during flue-curing in order to discover if this process plays any part in bringing about a condition of high sugar content in the cured leaf.

The curing of flue-cured tobacco is essentially a process of senescent respiration under abnormal conditions. The process of assimilation has been inhibited, but the leaf tissue is still actively alive and the process of respiration continues as long as there is any moisture left in the leaf. The general objective in flue-curing tobacco is to change a fresh greenish leaf containing from 75 to 90 per cent of water to one with a suitable bright yellowish colour and practically no moisture. The cured leaf must also possess commercially desirable texture, elasticity, body, and aroma. There are three distinct periods in flue-curing of tobacco: the yellowing stage, fixing the colour, and drying the leaf and stem. Furthermore, the whole process, which is complete inside of 72 to 96 hours, is managed by the proper control of temperature and ventilation.

In this experiment a number of comparable samples of tobacco were placed in the flue-curing kilns at the beginning of curing at the same location in the kiln. This tobacco was of the variety White Mammoth and was fertilized with a 2-10-8 mixture at the rate of 1,000 pounds per acre. Individual samples from this lot were taken from the kiln as curing progressed, at regular stated intervals, usually every 12 hours. The moisture content of these samples was determined, and the remainder was immediately preserved in alcohol for the analysis of carbohydrates. This sampling was continued until the tobacco was completely cured. The experiment has been repeated eight times on three different crops of tobacco with essentially the same results in every case. The curing of different primings has been compared, as well as tobaccos of different stages of maturity from the same priming.

The results of all these analyses are presented in tables 3 and 4. The results are given as a percentage of total dry weight. The kiln temperatures are also given in degrees F.

The first observation to be made is that the kiln temperature gradually rises. Stated briefly, the first stage called yellowing takes place at 98° to 102° approximately, and usually requires 24 to 36 hours. The fixing of the colour is done at 101° to 130°, and for the final drying of leaf and stem the temperature is raised to 170° to 180°. The actual details, of course, will vary with each kiln of tobacco, and besides this the ventilation must be carefully controlled.

As the temperature rises, the moisture content of the leaf gradually falls. In most cases the leaf loses very little moisture during the first 60 hours, but thereafter the moisture content drops suddenly and rapidly until it is practically zero at the end of curing. The first and second priming leaves usually have a smaller moisture content than those of the third priming, and the moisture seems to be more loosely held. For this reason the last period of curing is longer for the third priming, and the chemical changes take place more slowly.

As soon as the tobacco enters the kiln the soluble sugars in the leaf begin to increase. Dextrose, levulose, total reducing sugars, sucrose and total sugars all indicate a gradual rise. Vickery obtained the same result with shade-grown tobacco (33, 39). In every case the figure rises to a maximum and then begins to fall. This maximum point varies with the different primings and the different sugar fractions, but it shows a fairly consistent trend. With a few exceptions, levulose is the first sugar to reach its maximum, and sucrose is usually the last. In some cases the percentage of sucrose continues to increase until the very end of the curing process. Dextrose reaches its maximum between levulose and sucrose and at a point which can usually be taken as the general average for all the soluble carbohydrates as indicated by the total sugar percentage. For second priming leaves the general average maximum lies between the 48-hour point and the 60-hour point. For first priming leaves it is closer to the 48-hour point, and third priming leaves require 60 hours of curing or more before the maximum is reached. As will be seen from the tables, these changes are not small ones—but on the contrary the percentage of total sugars is multiplied

TABLE 3.—CARBOHYDRATE CHANGES IN FLUE-CURED TOBACCO DURING CURING—1935 AND 1936 CROPS

Description of sample	Date of sampling	Number of hours of curing	Dextrose (glucose)	Levulose (fructose)	Total reducing sugars	Sucrose	Total sugars	Dextrin	Starch	Total carbo-hydrates	Temperatures (Deg. F.) Inside dry	Inside wet	Outside dry	Outside wet
Second priming 1935.	Aug. 20	At beginning	....	....	3·46	2·49	5·95	·556	34·31	40·816	....	....	....	....
	" 21	After 14 hours	....	....	11·01	3·89	14·90	·378	18·08	33·358	....	....	....	....
	" 21	" 24 "	....	....	14·59	7·23	21·82	·509	13·70	36·029	....	....	....	....
	" 22	" 42 "	....	....	18·82	7·44	26·26	·532	6·98	33·772	....	....	....	....
	" 23	" 59 "	....	....	14·53	14·62	29·15	·326	2·82	32·296	....	....	....	....
	" 24	" 81 "	....	....	9·89	11·75	21·64	·876	3·84	26·356	....	....	....	....
Second priming—ripe 1936.	Aug. 18	At beginning	3·345	·641	3·98	2·41	6·38	·282	13·310	19·972	80	74	68	62
	" 19	After 12 hours	....	....	8·96	5·54	14·50	·220	9·918	24·638	96	90	80	68
	" 19	" 24 "	9·426	4·332	13·77	8·29	22·06	·041	8·660	30·761	102	96	74	70
	" 20	" 36 "	12·623	5·542	18·16	10·81	28·97	·010	2·002	30·982	98	88	65	60
	" 20	" 48 "	14·731	5·157	19·89	14·24	34·13	·182	1·734	36·046	130	100	66	60
	" 21	" 60 "	12·634	4·361	16·99	14·72	31·71	·004	1·292	33·006	162	110	67	61
	" 21	" 72 "	13·055	4·993	18·05	14·66	32·71	·027	2·623	35·360	195	....	68	63
	" 22	" 84 "	12·780	3·938	16·72	15·31	32·03	·016	1·862	33·908	....	....	....	....
Third priming—green 1936.	Sept. 17	At beginning	2·267	1·374	3·64	3·06	6·70	·141	17·660	24·501	74	70	53	50
	" 18	After 12 hours	3·423	2·518	5·95	3·92	9·86	·234	11·918	22·021	76	73	46	42
	" 18	" 24 "	5·988	3·585	9·59	5·56	15·15	·494	12·750	28·394	84	80	53	50
	" 19	" 36 "	9·126	5·921	15·06	4·06	19·12	·259	4·737	24·116	88	85	48	45
	" 19	" 48 "	14·343	6·598	20·96	6·81	27·77	·283	6·100	34·153	94	90	56	52
	" 20	" 60 "	16·402	5·715	22·11	7·89	30·00	·406	2·989	33·395	105	96	55	50
	" 20	" 72 "	10·797	6·014	16·83	5·24	25·07	·545	1·521	27·136	140	110	70	60
	" 21	" 84 "	6·505	3·705	10·21	9·31	19·51	·946	·923	21·379	160	....	60	58
	" 21	" 96 "	8·296	4·752	13·05	9·72	22·77	·083	·246	23·099	172	....	....	....
Third priming—ripe, 1936.	Sept. 17	At beginning	3·049	1·148	4·18	2·70	6·89	·025	19·905	26·820	74	70	53	50
	" 18	After 12 hours	3·512	1·306	4·81	2·79	7·60	·012	12·983	20·595	76	73	46	42
	" 18	" 24 "	8·106	4·013	12·12	5·89	18·01	·322	13·023	31·355	84	80	53	50
	" 19	" 36 "	8·153	5·664	14·81	5·63	20·45	·291	9·830	30·571	88	85	48	45
	" 19	" 48 "	13·627	6·725	20·35	6·65	27·01	·190	7·227	34·437	94	90	56	52
	" 20	" 60 "	16·766	7·342	24·10	7·77	31·87	·022	6·562	38·454	105	96	55	50
	" 20	" 72 "	16·401	7·563	23·95	8·32	32·28	·102	3·875	36·257	140	110	70	60
	" 21	" 84 "	13·703	5·666	19·37	10·58	29·95	·529	2·460	33·939	160	....	60	58
	" 21	" 96 "	10·228	5·848	16·07	9·18	25·25	·270	2·495	28·015	172	....	....	....

TABLE 4.—CARBOHYDRATE CHANGES IN FLUE-CURED TOBACCO DURING CURING—1937 CROP

Description of sample	Date of sampling	Number of hours of curing	Dex-trose	Levu-lose	Total reducing sugars	Sucrose	Total sugars	Dextrin	Starch	Hemi-cellu-lose	Total carbo-hydrates	Temperatures (Deg. F.) Inside dry	Inside wet	Outside dry	Outside wet
First priming 1937.	July 28	At beginning...	4·06	2·97	7·03	2·56	9·59	1·22	13·82	1·63	26·26	70	66	....	....
	" 29	After 12 hours	6·39	4·45	10·84	3·59	14·43	·39	4·30	2·01	21·13	88	82	....	....
	" 29	" 24 "	10·02	6·95	16·97	4·84	21·81	·28	5·56	1·19	28·84	100	84	....	....
	" 30	" 34 "	8·78	7·19	15·97	4·30	20·27	·08	·67	·76	21·78	118	100	....	....
	" 30	" 48 "	11·47	7·87	19·34	8·23	27·57	·33	·81	·94	29·65	144	102	....	....
	" 31	" 60 "	6·66	5·95	12·61	7·20	19·81	·22	·79	1·11	21·93	175	100	....	....
	" 31	" 72 "	4·92	4·18	9·10	6·98	16·08	·19	1·12	·86	18·25	178	dry	....	....
Second priming 1937.	Aug. 12	At beginning...	5·61	2·66	8·27	1·40	9·67	·63	22·83	4·95	38·08	80	78	....	....
	" 13	After 12 hours	8·10	3·76	11·86	3·53	15·39	·19	18·33	3·66	37·57	82	80	....	....
	" 13	" 24 "	9·26	4·36	13·62	4·68	18·30	·24	13·68	4·13	36·35	90	96	....	....
	" 14	" 36 "	10·95	7·38	18·33	3·16	21·49	·28	7·52	2·84	32·13	88	84	....	....
	" 14	" 48 "	12·84	9·23	22·07	6·08	28·15	·37	3·98	2·32	34·82	112	100	....	....
	" 15	" 60 "	14·53	9·13	23·66	9·23	32·89	·55	2·68	2·12	38·24	124	104	....	....
	" 15	" 72 "	11·84	7·59	19·43	11·37	30·80	·59	·13	2·13	33·65	140	108	....	....
	" 16	" 96 "	9·20	7·43	16·63	9·52	26·15	·81	·91	1·67	29·54	176	174	....	....
Third priming—green 1937.	Aug. 18	At beginning...	5·41	1·97	7·38	2·20	9·58	·52	22·27	3·50	35·87	85	78	64	64
	" 19	After 12 hours	8·44	4·25	12·69	4·43	17·12	·08	8·39	2·33	27·92	94	88	78	74
	" 19	" 24 "	11·28	5·78	17·06	4·09	21·15	·74	12·40	3·45	37·74	102	94	76	72
	" 20	" 36 "	13·35	7·18	20·53	7·84	28·37	·04	2·82	1·70	32·93	112	100	82	78
	" 20	" 48 "	13·84	7·25	21·09	8·91	30·00	·03	3·39	1·63	35·05	128	104	79	74
	" 21	" 60 "	16·08	6·37	22·45	8·61	31·06	·04	·64	1·76	33·50	140	110	....	....
	" 21	" 72 "	14·14	5·82	19·96	10·95	30·91	·05	·61	2·17	33·74	160	122	....	....
	" 23	" 96 "	8·59	5·51	14·10	10·52	24·62	·72	·59	1·92	27·85	170	dry	....	....
Third priming—ripe, 1937.	Aug. 18	At beginning...	5·56	2·26	7·82	2·06	9·88	·83	17·86	4·01	32·58	84	78	64	64
	" 19	After 12 hours	9·00	3·69	12·69	5·10	17·79	·06	14·17	2·02	34·04	94	88	78	74
	" 19	" 24 "	11·51	6·15	17·66	6·42	24·08	·32	6·81	1·83	33·04	102	94	76	72
	" 20	" 36 "	13·06	7·77	20·83	6·60	27·43	·07	3·33	2·74	33·78	112	100	82	78
	" 20	" 48 "	14·16	7·99	22·15	9·21	31·36	·07	1·63	1·47	34·53	128	104	79	74
	" 21	" 60 "	13·43	6·13	19·56	9·49	29·05	·32	·96	1·41	31·74	140	110	....	....
	" 21	" 72 "	12·76	5·05	17·81	10·57	28·38	·02	·12	1·53	30·05	160	122	....	....
	" 23	" 96 "	8·21	9·44	17·65	10·12	27·77	·32	·47	1·95	30·51	170	dry	....	....

three times in a period of 60 hours. After the maximum point is reached the percentage begins to fall, but in most cases it does not decrease a great deal before the final drying of the leaf occurs and all the moisture is driven off. Thereafter all chemical action ceases, and the leaf is permanently fixed with the amount of sugars it contains at the end of curing.

As the soluble carbohydrates increase, the insoluble fractions decrease. A good quality leaf of second or third priming enters the kiln with a fairly high percentage of starch, in some cases more than 20 per cent of the dry matter. As soon as the leaf enters the kiln this percentage begins to fall rapidly. The most sudden and rapid drop is usually during the first 12-hour period and thereafter the starch decreases gradually, until at the end of curing practically all the starch has been converted to sugar. There is always a small quantity of unconverted starch left in the leaf but the amount is usually less than one per cent. In some cases the figures in the accompanying tables do not indicate the above trends consistently, but this is largely due to sampling error, since it is extremely difficult to obtain such a great number of exactly comparable samples at each stage of maturity. However, the general trend is quite apparent and is the same in every series.

The general decrease in percentage that occurs with starch takes place also with the other insoluble carbohydrates but with much less consistency, mainly because they are not essentially storage products. Dextrin is a transformation product in carbohydrate metabolism, and exists in only relatively small quantities. Hemicellulose performs certain functions in supporting the structure of the leaf, and may be used for other purposes as well. However, both these substances show some signs of breakdown into soluble sugars during the curing process, and in almost every case the percentage is smaller at the end of curing than at the beginning.

Although starch is the main storage product of the leaf, and dextrin and hemicellulose act in this capacity as well, these insoluble carbohydrate fractions cannot fully account for the high percentages of sugar which are built up in the leaf during curing as a result of the abnormally rapid respiration. Furthermore, under ordinary circumstances, the starch will not give rise to levulose and sucrose, unless additional transformations and condensations occur after its breakdown into dextrose. Therefore, it would appear that some other reserve carbohydrate substances are entering into these reactions, possibly glucosides. Organic acids may also take part in some manner although they are generally considered to be decomposition products of the soluble sugars.

Comparing the different primings it will be seen that the second priming leaves always reach the highest maximum of total sugars, being well over 30 per cent in most cases with the final percentage almost as high. Third priming leaves do not attain as high a maximum, and first priming leaves are still lower. This corroborates the hypothesis that quality in flue-cured tobacco is closely associated with soluble sugars, since the second priming leaves always represent the best of the crop, with third priming leaves coming second, and first and fourth primings representing the poorest quality.

For two years an experiment has been conducted for the comparison of the results obtained with leaves of two different stages of maturity at time of curing. Third priming leaves which were not quite matured are compared with ones which are fully ripe. There is very little difference in the two series, but the ripe leaves show a slightly higher maximum and final percentage of total soluble sugars in both series than the samples which were just a little green at time of harvesting. From this it would be concluded that it is the best policy to allow the tobacco to ripen in the field before harvesting in order to obtain the best quality leaf.

Studies with the Growing Plant

On the basis of the foregoing results it may be stated that since carbohydrates in the form of soluble sugars are essential for quality, and since these sugars arise largely from the re-conversion of stored starch during the curing process, the problem resolves itself, therefore, into one of obtaining leaves with a high quantity of stored starch before curing. This involves a study of photosynthetic activity, and the following questions must be answered—(1) what carbohydrate conditions exist in the leaves of flue-cured tobacco just prior to harvesting? (2) what changes take place due to weather and seasonal conditions? (3) what effect does the priming method of harvesting have upon the various carbohydrate fractions of the leaf? (4) and finally, how may the grower take advantage of natural conditions so as to obtain a maximum percentage of starch in the leaf at time of harvest?

In an effort to find an answer to some of these questions as a preliminary study, several series of plants were taken directly from the field for carbohydrate analysis. Samples were taken during the ripening period just prior to harvesting from three succeeding crops. This tobacco was also of the variety White Mammoth and fertilized with a 2-10-8 mixture at the rate of 1,000 pounds per acre.

The practice of priming flue-cured tobacco consists of picking off the leaves as they ripen, beginning with the bottom leaves (25). This allows the remaining leaves to ripen to better advantage. The first priming consists of the first three or four leaves at the bottom of the plant, sometimes called the sand leaves if these have not already been discarded. The second priming leaves are the next three or four up the stalk and so forth. Sometimes as many as four or five primings are made on a single plant. The best quality leaves are found in the second priming.

The first comparison to be shown is that between different primings. The complete carbohydrate analysis is given in tables 5 and 6 for the different primings, early, medium, and late from samples taken three different years. In the third year the samples were taken over a longer period of time particularly with the fourth priming. The figures in tables 5 and 6 give a fairly clear picture of carbohydrates relations existing in the leaf during the ripening stages. The content of reducing sugars varies considerably, with the dextrose fraction predominating. The percentage of starch is always the largest individual fraction, and in some cases this percentage reaches a very high value. Dextrin, which is a conversion product, is a relatively unimportant fraction and exists only in small quantities in the leaf. Hemicellulose is a secondary reserve carbohydrate substance, but is found in larger quantities than dextrin.

Comparing the different primings it will be seen that the second priming leaves almost always contain the highest percentage of sugars and starch. The figures for third priming leaves are usually slightly lower than those for the second priming leaves although in some cases the reverse is true. The percentages of sugars in the first and fourth primings are almost as high as those for second and third, but the percentage of starch is definitely lower, particularly in the first priming. This indicates a lower potential sugar supply for the cured leaf, and therefore a poorer quality. As mentioned previously, this is always the case—second and third priming leaves are always of better quality than first and fourth.

In practically every case the figures in tables 5 and 6 show that there is no appreciable accumulation of any of the carbohydrate fractions during the last stages of maturity. This result is in agreement with those of other investigations which show that carbohydrate accumulation is not a seasonal effect and in many plants more than half the carbohydrate content accumulated at the end of the day disappears during the night, and the diurnal fluctuations are more significant than seasonal trends.

TABLE 5.—COMPARISON OF CARBOHYDRATE FRACTIONS OF DIFFERENT PRIMINGS—1935 AND 1936 CROPS

Description of Sample	Date of sampling	Dextrose	Levulose	Total reducing sugars	Sucrose	Total sugars	Dextrin	Starch	Total carbo-hydrates
Second Priming 1935—Early	Aug. 13	....	....	1·83	2·14	3·97	·35	29·78	34·10
" " " —Medium	Aug. 16	....	....	3·95	1·50	5·75	·32	28·94	35·01
" " " —Late	Aug. 19	....	....	2·10	1·15	3·25	·39	35·00	38·64
Third Priming 1935—Early	Aug. 16	....	....	2·76	1·13	3·90	·21	23·98	28·09
" " " —Medium	Aug. 22	....	....	....	....	....	·35	38·60	....
" " " —Late	Aug. 27	....	....	1·41	·79	2·20	·51	39·26	41·97
Second Priming 1936—Early	Aug. 10	3·45	·82	4·27	2·39	6·56	·47	11·71	18·74
" " " —Medium	Aug. 17	4·35	·98	5·33	2·29	7·62	·24	14·21	22·07
" " " —Late	Sept. 8	3·13	·00	3·13	1·58	4·71	·10	6·30	11·11
Third Priming 1936—Early	Sept. 8	3·13	·75	3·87	1·57	5·45	·04	8·38	13·87
" " " —Medium	Sept. 16	1·96	·11	2·07	1·98	4·06	·27	7·53	11·86
" " " —Late	Sept. 17	3·46	·01	3·45	1·61	5·06	·38	17·54	22·98
Fourth Priming 1936—Early	Sept. 22	1·70	·24	1·93	2·18	4·10	·09	13·43	17·62

NOTE.—All figures in all tables calculated to a dry matter basis.

TABLE 6.—COMPARISON OF CARBOHYDRATE FRACTIONS OF DIFFERENT PRIMINGS—1937 CROP

Description of Sample	Date of sampling	Dextrose	Levulose	Total reducing sugars	Sucrose	Total sugars	Dextrin	Starch	Hemicellulose	Total carbohydrates	Nitrogen	Carbohydrate / Nitrogen ratio
First Priming —Early	July 29	4·39	3·72	8·11	2·16	10·27	·58	13·87	1·06	25·78	1·25	20·6
" " —Medium (optimum)	July 28	4·06	2·97	7·03	2·56	9·59	1·22	13·82	1·63	26·26	1·18	22·3
" " —Late	July 30	4·85	2·93	7·08	2·28	9·36	·91	13·50	1·79	25·26	....	....
Second Priming—At time of 1st priming	July 28	6·43	3·43	9·86	2·29	12·15	·67	20·91	3·04	36·77	1·09	33·2
" " —Early	Aug. 5	7·51	3·49	11·00	1·07	12·07	·28	15·95	2·66	30·96	1·27	24·4
" " —Medium	Aug. 12	5·61	2·66	8·27	1·40	9·67	·63	22·83	4·95	38·08	1·17	32·6
" " —Late	Aug. 13	4·42	1·44	5·86	1·82	7·68	·08	21·05	3·46	32·27	1·06	30·4
Third Priming—At time of 1st priming	July 28	6·90	3·03	9·93	2·73	12·66	·56	19·76	4·41	37·39	1·44	26·1
" " — " " of 2nd priming	Aug. 12	....	....	7·78	1·08	8·86	·37	19·83	4·37	33·43	1·30	25·7
" " —Early	Aug. 18	5·41	1·97	7·38	2·20	9·58	·52	22·27	3·50	35·87	1·16	30·9
" " —Medium	Aug. 18	5·56	2·26	7·82	2·06	9·88	·83	17·86	4·01	32·58	1·11	29·4
" " —Late	Aug. 19	5·45	1·47	6·92	1·98	8·90	·60	23·09	4·13	36·72	·88	41·8
Fourth Priming—At time of 1st priming	July 28	4·63	1·91	6·54	2·26	8·80	·85	19·85	3·68	33·18	1·69	19·7
" " — " " of 2nd priming	Aug. 12	4·11	·93	5·04	1·27	6·31	·52	20·70	5·71	33·24	1·60	20·8
" " — " " of 3rd priming	Aug. 18	5·68	·85	6·53	1·98	8·51	·13	17·34	3·50	29·48	1·30	22·7
" " —Early	Aug. 25	3·65	·19	3·84	1·95	5·79	·38	18·95	3·27	28·39	1·25	22·8
" " —Medium	Aug. 30	3·94	·00	3·94	1·77	5·71	·06	17·17	3·52	25·46	1·19	21·4
" " —Late	Sept. 1	3·62	·59	4·21	2·18	6·39	·38	17·31	5·17	29·25	1·05	27·8

Since sunlight is one of the essential factors in the photosynthesis of carbohydrates, the daily record of hours of sunshine and inches of rainfall should show some correlation with the carbohydrate conditions in the leaf. In order to discover some relation, the weather records for the three seasons 1935, 1936 and 1937 were studied and the data are presented in table 7. The sampling dates are also marked * for convenience. The correlation is shown in a broad way with the carbohydrate figures of the 1936 crop. The 1936 season was quite unusual in that a severe drought occurred during the first part of August. During this period the leaves ripened rapidly, in many cases rim-burning and scorching occurred, and the starch content of the leaf rose to a high level. When the

TABLE 7.—WEATHER CONDITIONS DURING PRIMING EXPERIMENTS

1935 Season			1936 Season			1937 Season		
Date	Hours of sunshine	Inches of rainfall	Date	Hours of sunshine	Inches of rainfall	Date	Hours of sunshine	Inches of rainfall
*Aug. 1	11·4	·07	Aug. 1	12·2		July 20	12·7	
Aug. 2	0	·10	Aug. 2	12·4		July 21	11·4	
Aug 3	2·8		Aug. 3	4·7		July 22	11·6	
Aug. 4	10·5		Aug. 4	·1		July 23	11·6	
Aug. 5	12·3		Aug. 5	3·2		July 24	4·8	·05
Aug. 6	0	·35	Aug. 6	11·1		July 25	1·3	·36
Aug. 7	0	·04	Aug. 7	11·4		July 26	3·6	
Aug. 8	0		Aug. 8	11·9		July 27	5·0	
Aug. 9	5·8		Aug. 9	10·5		*July 28	12·2	
Aug. 10	9	2·7	*Aug. 10	5·6		*July 29	10·7	
Aug. 11	11·9		Aug. 11	12·1		*July 30	11·8	·07
Aug. 12	10·0		Aug. 12	10·8		July 31	11·2	
*Aug. 13	2·4	·71	Aug. 13	10·5	·01	Aug. 1	10·4	
Aug. 14	11·8		Aug. 14	2·0		Aug. 2	9·2	
Aug. 15	12·9		Aug. 15	5·8		Aug. 3	11·8	
*Aug. 16	12·1		Aug. 16	10·5		Aug. 4	2·3	
Aug. 17	10·4		*Aug. 17	12·0		*Aug. 5	10·7	
Aug. 18	10·9		Aug. 18	8·0		Aug. 6	7·5	·07
*Aug. 19	12·0		Aug. 19	6·0	·85	Aug. 7	1·0	·01
Aug. 20	10·8		Aug. 20	11·7	·05	Aug. 8	5·9	1·07
Aug. 21	7·8	·47	Aug. 21	3·2	·10	Aug. 9	0	1·25
*Aug. 22	12·6		Aug. 22	4·4	·16	*Aug. 10	·7	·49
Aug. 23	12·1		Aug. 23	7·0	·02	Aug. 11	6·8	
Aug. 24	11·9		Aug. 24	12·7		*Aug. 12	3·5	·33
Aug. 25	6·5		Aug. 25	3·4	·07	*Aug. 13	12·5	
Aug. 26	10·0		Aug. 26	2·4		*Aug. 14	11·9	
*Aug. 27	6·8	·59	Aug. 27	8·6		Aug. 15	9·7	
Aug. 28	6·1		Aug. 28	1·1	·17	*Aug. 16	11·3	
Aug. 29	6·9		Aug. 29	8·4		Aug. 17	3·8	
Aug. 30	·5	·08	Aug. 30	2·2		*Aug. 18	10·6	·32
Aug. 31	8·9		Aug. 31	11·4		*Aug. 19	0	
			Sept. 1	4·8	·03	Aug. 20	11·6	
			Sept. 2	·2	·02	Aug. 21	1·3	
			Sept. 3	6·3		Aug. 22	7·8	
			Sept. 4	9·8		Aug. 23	2·4	
			Sept. 5	10·1		*Aug. 24	7·6	
			Sept. 6	5·5	·04	*Aug. 25	11·4	
			Sept. 7	4·9	1·25	*Aug. 26	11·0	
			*Sept. 8	8·3		Aug. 27	10·5	
			Sept. 9	8·9		Aug. 28	0	
			Sept. 10	9·5		Aug. 29	2·5	
			Sept. 11	6·9	·61	*Aug. 30	8·2	
			Sept. 12	1·6		*Aug. 31	8·2	
			Sept. 13	·2	·05			
			Sept. 14	1·3	·02			
			Sept. 15	7·9	·20			
			*Sept. 16	4·5	·10			
			*Sept. 17	7·8				
			Sept. 18	8·8				
			Sept. 19	9·6				
			Sept. 20	8·8				
			Sept. 21	8·3				
			*Sept. 22	9·1				

NOTE.—Sampling dates are marked *.

drought broke, a period of dull rainy weather set in, the tobacco became green again, and did not ripen for a considerable time, thereby causing a late harvest. During this dull rainy weather the stores of starch in the leaves were seriously depleted and were not built up again until just before harvesting commenced.

In order that these changes might be followed more closely, two series of samples were taken from the 1937 crop showing the effects upon the starch content of a rainy period followed by sunshine. The results of analysis of these two series are presented in table 8. In both cases the dull rainy period was not of long enough duration to cause a serious decrease in the supply of starch, with the result that in the succeeding bright period there was only a slight increase in starch. It is evident from these results that there are still other factors to be considered in studying the building up of carbohydrates in the tobacco leaf.

A further study was made with the samples from the 1937 crop—total nitrogen was determined and the carbohyrate-nitrogen ratio was calculated. As the figures in table 6 indicate, the nitrogen in the leaf decreased in percentage steadily as the season progressed. The carbohydrate-nitrogen ratio failed to show any consistent trend.

Discussion

It is evident from the results which have been presented that carbohydrates in the form of soluble sugars are associated with quality in flue-cured tobacco. A direct relationship has been found to exist between the amount of soluble sugars present and quality in the cured leaf. It has also been shown that during the curing process starch and other insoluble polysaccharides are converted into soluble sugars under abnormal conditions of respiration with a consequent accumulation of these constituents. This process must be rigidly controlled and should be so manipulated that colour fixation in the leaf is completed before the sugars begin to decline and at a point where nearly all the starch has been converted to sugar. It must be so controlled as to prevent a condition of the leaf known as "sponging" which is caused by the presence of too much moisture during the late yellowing stage. This condition definitely lowers the quality of the finished product. Dull-coloured sponged leaves are always lower in soluble sugars. Leaves which cure out with green spots or tips due to improper handling are also low in sugars and of inferior quality.

A leaf with a relatively high starch content at harvesting possesses the potential elements of quality as far as carbohydrates are concerned. The production of starch in the growing leaf depends on the photosynthetic activity within the cells of that leaf. Although water, carbon dioxide, chlorophyll and sunlight are the essential elements in photosynthesis, there are, however, many other factors which exert some influence on the process and which must be taken into consideration. The nature, duration and intensity of light are all individual factors in this respect. Rainfall during the ripening period is another factor. Temperature has an indirect bearing. As stated by Tottingham (32) the accumulation of the products of photosynthesis will be impeded by losses due to increased respiratory activity at higher temperatures. In 1920 Garner and Allard (10) introduced the principle of photoperiodism or regulatory action of the length of day in either initiating or inhibiting sexual reproduction in plants. This phenomenon was found to have a marked effect on the form of carbohydrate stored by the plant. Nitrogen and potassium are also indirect factors affecting the rate of photosynthesis. Janssen and Bartholemew (16) have investigated carbohydrate-potassium relations in the tomato plant, and showed that a high percentage of carbohydrate in the leaf tissue is associated with a rich supply of potassium, while Kraus and Kraybill (18) have shown that with the approach of maturity and seed production, the nitrogen in the plant decreases and the carbohydrate increases. Therefore, it is evident that with the approach of maturity or ripening a series of complex changes occurs simultaneously within the plant. Nitrogen decreases, carbohydrates increase, repro-

TABLE 8.—EFFECT OF WEATHER ON CARBOHYDRATES FRACTIONS—1937 CROP

Description of Sample	Date of sampling	Dextrose	Levulose	Total reducing sugars	Sucrose	Total sugars	Dextrin	Starch	Hemicellulose	Total carbohydrates	Nitrogen	Carbohydrate / Nitrogen ratio
Second priming—After prolonged rainy period before sun reappeared.........	Aug. 10	6·58	3·36	9·94	1·41	11·35	·17	18·62	3·81	33·95	1·16	29·2
Second priming—After prolonged rainy period followed by one day of sunshine.	Aug. 13	5·79	3·09	8·88	1·91	10·79	·31	19·06	3·53	33·69	1·13	29·9
Second priming—After prolonged rainy period followed by two days of sunshine.	Aug. 14	5·83	3·11	8·94	1·89	10·83	·36	19·59	4·14	34·92	1·00	34·8
Third priming—After prolonged rainy period before sun reappeared...........	Aug. 24	4·18	1·46	5·64	1·67	7·31	·35	20·84	3·67	32·17	1·17	27·6
Third priming—After prolonged rainy period followed by one day of sunshine.	Aug. 25	4·29	·80	5·09	2·10	7·19	·41	22·29	3·33	33·22	1·04	31·9
Third priming—After prolonged rainy period followed by two days of sunshine.	Aug. 26	4·18	1·55	5·73	1·77	7·50	·56	17·61	3·41	28·70	·97	29·7

duction is induced, and all these changes may be initially stimulated by the decreased length of day. The practice of topping and suckering tobacco introduces another factor in the consideration of starch accumulation. By cutting off the flowering part of the plant the reproductive function is inhibited, ripening is delayed and the vegetative period is prolonged. Thus a greater yield is obtained, but it is possible that the nitrogen content does not decrease normally and carbohydrate synthesis may be delayed. Before the accumulation of starch and maturity of leaf are fully understood, all of these factors will have to be considered individually and in combination. At the present time there is some evidence of a slight building up of starch during the last stages of maturity but it appears advisable to harvest flue-cured tobacco after a period of sunshine if at all possible, rather than immediately after a dull rainy period.

Summary

1. The results of chemical analyses are presented to show that in general the percentage of soluble sugars in flue-cured tobacco is directly proportional to quality.

2. Analysis of comparable samples of leaf throughout the curing process indicates that soluble sugars increase and insoluble polysaccharides decrease throughout the curing process. Inferior sponged leaf usually has a lower sugar content than comparable leaf properly cured.

3. Analysis of leaf samples taken directly from the field shows that there is a slight building up of starch during the last stages of maturity, but many factors influence this photosynthetic activity in the growing leaf.

4. The effect of sunshine and rain on starch accumulation is discussed and figures are presented to show that the percentage falls after a dull rainy period but rises again after a period of bright sunshine.

5. The relation of maturity and nitrogen to starch accumulation is discussed.

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CARBOHYDRATES IN CIGAR TOBACCO

Introduction

In cigar tobacco the carbohydrates play an altogether different role and a much less important one than in the flue-cured type. In the growing plant they perform the same functions, but the method of harvesting together with subsequent treatments causes a different set of chemical reactions to take place. In the harvesting of Canadian cigar tobacco the leaves do not become yellow in the field as is the case with flue-cured tobacco, and hence the priming method is not used. The process employed is the stalk-cutting method in which the stalk of the plants is cut at the base and without removing any leaves the stalk is speared onto a lath. The lath holding six plants is hung up in the curing barns with the leaves hanging in an upside down position.

Maturity Studies

A survey of the carbohydrate relations in cigar tobacco during the maturity or ripening stages, i.e., from topping time until harvesting—was made on the 1935, 1936 and 1937 crops. This period is usually of three weeks duration, and samples were taken at weekly intervals. Three representative plants were taken from a plot that had received a standard basal fertilizer ration, and the leaves were sorted into three lots for analysis—bottoms, middles, and tops. Table 1 shows the percentages of carbohyrates present in these leaves. There seems to be no consistent change in the sugars during the period under consideration, although they show a certain amount of variation both up and down. On the other hand there is some slight indication that the starches are built up to a certain degree during this period. This rise, however, is not very consistent, particularly in the tops, and seems to have been influenced by some other factor. In an attempt to account for the discrepancies, a study was made of the weather conditions immediately preceding each sampling, and in table 2 there is given a record of the daily hours of sunshine and inches of rainfall during the periods under consideration. Sampling dates are indicated on the table. While this does not fully explain the discrepancies in all cases, it will be seen that in most cases, where there were several days of continuous sunshine and no rain preceding the sampling, the starch percentage is usually higher, but where there is very little sunshine accompanied by rainfall preceding the sampling, the starch percentage is low. It will be observed particularly that in the 1936 season the choice of sampling dates was rather unfortunate in this respect, being preceded in every case by very little sunshine and a considerable rainfall. Furthermore, the total amount of sunshine during the whole period was much less than in the corresponding period for 1935. These facts are directly reflected in the much smaller starch percentages found in the 1936 samples. During the whole period the starch remained at a very low level.

Air-Curing

Cigar tobacco is air-cured and ordinarily it is not necessary to furnish artificial heat. Contrary to flue-curing, air-curing is a long-time process, and normally requires two to three months for completion. Consequently a different set of chemical reactions occurs in the leaf during this long period of wilting and drying. The process was investigated during the present carbohydrate study, but only one sampling for analysis was made on the 1935 crop. This sample

TABLE 1.—CARBOHYDRATE CHANGES IN CIGAR TOBACCO—1935 AND 1936 CROPS

Description of Sample	Date of sampling	Reducing sugars	Sucrose	Total sugars	Dextrin	Starch	Total carbo-hydrates
5 bottom leaves—Topping stage	Aug. 9, 1935	5·16	2·51	7·67	·24	5·79	13·69
5 " " —One week after	Aug. 16, 1935	6·12	2·78	8·90	·59	1·37	10·86
5 " " —Two weeks after	Aug. 23, 1935	7·34	2·42	9·76	·34	3·57	13·67
5 " " —Harvesting	Aug. 30, 1935	6·06	2·63	8·69	·31	5·61	14·61
Half cured samples	Sept. 12, 1935	1·84	·32	2·16	·49	·60	3·25
5 middle leaves—Topping stage	Aug. 9, 1935	5·88	2·90	8·78	·29	8·95	18·02
5 " " —One week after	Aug. 16, 1935	6·56	2·40	8·96	·42	4·36	13·74
5 " " —Two weeks after	Aug. 23, 1935	6·12	2·51	8·63	·40	5·76	14·79
5 " " —Harvesting	Aug. 30, 1935	4·67	2·64	7·31	·42	7·09	14·82
Half cured samples	Sept. 12, 1935	4·06	·55	4·61	·45	·75	5·81
5 top leaves—Topping stage	Aug. 9, 1935	3·34	2·49	5·83	·29	5·46	10·58
5 " " —One week after	Aug. 16, 1935	4·52	3·80	8·32	·47	8·16	16·96
5 " " —Two weeks after	Aug. 23, 1935	3·57	3·48	7·05	·44	8·06	15·55
5 " " —Harvesting	Aug. 30, 1935	2·41	2·25	4·66	·32	7·37	12·35
Half cured samples	Sept. 12, 1935	1·37	1·25	2·62	·34	·50	3·46
5 bottom leaves—Topping stage	Aug. 17, 1936	3·60	1·56	5·15	·40	·83	6·38
5 " " —One week after	Aug. 24, 1936	3·49	1·34	4·83	·05	1·04	4·92
5 " " —Two weeks after	Sept. 2, 1936	4·08	1·67	5·75	·03	1·50	7·28
5 " " —Harvesting	Sept. 9, 1936	3·06	1·55	4·61	·15	2·00	6·76
5 middle leaves—Topping stage	Aug. 17, 1936	4·92	1·82	6·74	·32	1·50	8·56
5 " " —One week after	Aug. 24, 1936	3·11	1·87	4·98	·25	1·53	6·76
5 " " —Two weeks after	Sept. 2, 1936	5·00	2·12	7·12	·02	2·27	9·41
5 " " —Harvesting	Sept. 9, 1936	3·20	2·33	5·53	·16	1·71	7·40
5 top leaves—Topping stage	Aug. 17, 1936	6·66	·00	6·66	·26	1·66	8·58
5 " " —One week after	Aug. 24, 1936	1·56	2·55	4·11	·17	1·59	6·87
5 " " —Two weeks after	Sept. 2, 1936	2·13	2·43	3·56	·03	2·82	7·41
5 " " —Harvesting	Sept. 9, 1936	3·47	·27	3·74	·08	1·52	5·34

TABLE 1.—CARBOHYDRATE CHANGES IN CIGAR TOBACCO—1937 CROP—*Concluded*

Description of Sample	Date of Sampling	Dextrose	Levulose	Total reducing sugars	Sucrose	Total sugars	Dextrin	Starch	Hemi-cellulose	Total carbo-hydrates	Total nitrogen	Carbohydrate / Nitrogen ratio
5 bottom leaves—Topping stage....	Aug. 12, 1937	2·49	·08	2·57	·93	3·50	·93	·22	1·88	6·53	3·43	1·9
5 " " —One week after topping........	Aug. 19, 1937	1·05	2·41	3·46	1·16	4·62	·28	·26	1·68	6·84	3·59	1·9
5 " " —Two weeks after topping........	Aug. 26, 1937	2·49	·20	2·69	·48	3·17	·19	·06	1·92	5·34	3·50	1·5
5 " " —Three weeks after topping........	Sept. 2, 1937	2·54	·30	2·84	2·84	5·63	·40	1·95	2·26	10·29	3·09	3·1
5 middle leaves—Topping stage....	Aug. 12, 1937	2·76	·87	3·63	1·03	4·66	·01	·39	1·96	7·02	4·60	1·5
5 " " —One week after topping........	Aug. 19, 1937	·98	2·25	3·23	·56	3·69	·34	·38	2·57	7·08	4·60	1·6
5 " " —Two weeks after topping........	Aug. 26, 1937	2·79	1·17	3·96	·93	4·89	·15	·28	2·21	7·53	4·71	1·6
5 " " —Three weeks after topping........	Sept. 2, 1937	3·27	·97	4·24	1·72	5·96	·10	2·91	2·45	11·42	3·94	2·9
5 top leaves—Topping stage........	Aug. 12, 1937	2·14	2·08	4·22	·97	5·19	·01	·53	·85	6·58	5·63	1·2
5 " " —One week after topping..............	Aug. 19, 1937	2·57	·00	2·57	1·39	3·96	·40	3·52	2·80	10·68	5·64	1·9
5 " " —Two weeks after topping..............	Aug. 26, 1937	2·20	·41	2·61	1·27	3·88	·20	1·17	2·85	8·10	5·17	1·6
5 " " —Three weeks after topping...........	Sept. 2, 1937	....	....	2·66	1·93	4·59	·11	2·60	2·57	9·87	4·50	2·2

TABLE 2.—WEATHER CONDITIONS DURING PERIOD OF RIPENING

Date 1935	Hours of sunshine	Inches of rainfall	Date 1936	Hours of sunshine	Inches of rainfall	Date 1936	Hours of sunshine	Inches of rainfall	Date 1937	Hours of sunshine	Inches of rainfall	Date 1937	Hours of sunshine	Inches of rainfall
Aug. 1..	9·9	....	Aug. 1..	7·0	....	Sept. 1..	8·9	....	Aug. 1..	8·9	·02	Sept. 1..	8·2	....
Aug. 2	13·3	....	Aug. 2..	0	....	*Sept. 2..	9·4	....	Aug. 2..	9·1	....	*Sept. 2..	10·7	....
Aug. 3..	10·7	....	Aug. 3..	2·9	....	Sept. 3..	5·4	....	Aug. 3..	11·1	·01			
Aug. 4..	5·1	·20	Aug. 4..	12·5	....	Sept. 4..	8·1	....	Aug. 4..	1·8	·02			
Aug. 5..	5·9	·12	Aug. 5..	10·9	....	Sept. 5..	8·2	....	Aug. 5..	12·5	....			
Aug. 6..	9·3	....	Aug. 6..	9·3	....	Sept. 6..	8·3	·02	Aug. 6..	11·8	....			
Aug. 7..	11·5	....	Aug. 7..	13·0	....	Sept. 7..	·2	·23	Aug. 7..	....	·02			
Aug. 8..	12·8	....	Aug. 8..	11·8	....	Sept. 8..	4·6	....	Aug. 8..	4·5	·05			
*Aug. 9..	12·7	....	Aug. 9..	10·1	....	*Sept. 9	5·2	....	Aug. 9..	5·0	·04			
Aug. 10..	7·8	....	Aug. 10..	8·5	....				Aug. 10..	2·2	·95			
Aug. 11..	9·8	·06	Aug. 11..	13·5	....				Aug. 11..	....	·37			
Aug. 12..	10·8	·06	Aug. 12..	10·4	....				*Aug. 12..	4·7	·26			
Aug. 13..	7·2	....	Aug. 13..	4·1	....				Aug. 13..	9·5	·02			
Aug. 14..	12·6	....	Aug. 14..	5·5	1·10				Aug. 14..	13·2	....			
Aug. 15..	12·5	....	Aug. 15..	0	·36				Aug. 15..	9·5	....			
*Aug. 16..	12·8	....	Aug. 16..	3·9	·07				Aug. 16..	11·7	·05			
Aug. 17..	12·6	....	*Aug. 17..	13·4	....				Aug. 17..	6·1	....			
Aug. 18..	12·5	....	Aug. 18..	11·0	....				Aug. 18..	13·1	....			
Aug. 19..	12·7	....	Aug. 19..	9·3	....				*Aug. 19..	2·9	1·49			
Aug. 20..	9·0	·32	Aug. 20..	10·4	....				Aug. 20..	3·0	....			
Aug. 21..	2·5	·22	Aug. 21..	2·5	·20				Aug. 21..	2·1	....			
Aug. 22..	8·5	....	Aug. 22..	0	·12				Aug. 22..	13·2	·22			
*Aug. 23..	11·0	....	Aug. 23..	3·0	·16				Aug. 23..	12·3	....			
Aug. 24..	10·7	....	*Aug. 24..	5·0	....				Aug. 24..	12·7	....			
Aug. 25..	13·2	....	Aug. 25..	2·4	....				Aug. 25..	12·1	....			
Aug. 26..	11·7	·10	Aug. 26..	8·8	....				*Aug. 26..	12·1	....			
Aug. 27..	7·5	....	Aug. 27..	12·1	....				Aug. 27..	11·2	....			
Aug. 28..	8·8	....	Aug. 28..	7·3	·72				Aug. 28..	12·4	....			
Aug. 29.	12·7	....	Aug. 29..	5·7	....				Aug. 29..	11·8	....			
*Aug. 30.	0	·10	Aug. 30..	·6	·22				Aug. 30..	9·0	....			
Aug. 31..	6·5	·02	Aug. 31	1·9	·02				Aug. 31..	10·8	....			

was taken about two weeks after the commencement of curing. The bottoms, middles, and tops, were sorted and analysed separately, in the same nanner as the samples of cigar tobacco previously discussed. The results of this analysis have been included in table 1, and the samples are designated as half-cured samples. It will be seen that the percentage of every constituent has fallen to a small fraction of its former value. The starch has almost disappeared entirely.

Fermentation

After cigar tobacco is completely cured, it is stripped, sorted, and graded. When grading is complete it is submitted to the fermentation process in order that it may be rendered fit for consumption and develop a characteristic flavour and aroma. This is accomplished by placing the tobacco in large piles and allowing it to heat. The entire process requires a period of about six weeks, and the tobacco is taken down and re-piled every 7 to 10 days in order to prevent the fermentation from becoming too active. This process is known as "bulking" and each pile is known as a different "bulk." During a chemical investigation of the fermentation process, the carbohydrates were studied, comparable samples of tobacco being taken from the pile for analysis after each bulk to observe the progressive effect of the process. The results of this investigation are shown in table 3.

TABLE 3.—CARBOHYDRATE CHANGES DURING FERMENTATION

Leaf-grade	Fermentation treatment time of sampling	Reducing sugars	Total sugars	Dextrin	Starch	Total carbohydrates
Bottom darks.	Before fermentation	1·58	1·58	·99	·03	2·60
	After first bulk	·19	·19	·02	·45	·66
	" second bulk	·42	·42	·04	·03	·49
	" third bulk	·03	·13	·16	·00	·29
	" complete fermentation	·04	·10	·82	·00	·92
Middle darks.	Before fermentation	1·54	1·54	·85	·82	3·21
	After first bulk	·47	·47	·02	·39	·88
	" second bulk	·13	·28	·81	·07	1·16
	" third bulk	·34	·36	·05	·00	·41
	" complete fermentation	·11	·11	·19	·00	·30
Middle lights.	Before fermentation	1·17	1·17	·14	·39	1·70
	After first bulk	·19	·19	·12	·20	·51
	" second bulk	·28	·28	·24	·16	·68
	" third bulk	·07	·08	·06	·00	·14
	" complete fermentation	·28	·28	·87	·00	1·15
Top darks..	Before fermentation	·28	·34	·68	·50	1·52
	After first bulk	·55	·55	·77	·00	1·32
	" second bulk	·03	·39	·20	·00	·59
	" third bulk	·19	·19	·57	·00	·76
	" complete fermentation	·29	·29	·07	·00	·36
True tops..	Before fermentation	·40	·40	1·04	·24	1·68
	After first bulk	·44	·53	·08	·07	·68
	" second bulk	·13	·31	·38	·00	·69
	" third bulk	·08	·10	·11	·11	·32
	" complete fermentation	·08	·08	·81	·03	·92

It will be seen that after curing and before fermentation, there was still a small quantity of carbohydrates present in all leaves. But with the first bulk most of this disappeared and by the end of the fermentation process after four bulks it had diminished to a negligible quantity in the case of the sugars, and the starches had disappeared entirely. This means that cigar tobacco when ready for the consumer contains no carbohydrates beyond slight traces, and hence quality in cigar tobacco has no connection with the carbohydrates which are so important to the quality of flue-cured tobacco.

Summary

Results of carbohydrate analysis on cigar tobacco are presented to prove that carbohydrates are not important in the determination of quality in this type, as is the case with flue-cured tobacco. The changes in carbohydrates are traced through the maturity stages of growth, through the curing and fermentation processes. Most of the sugars and starches in the leaf disappear during the long period of air-curing, and any traces remaining thereafter are reduced to a negligible fraction during fermentation. The result is that in the finished product carbohydrates play a very unimportant role.

APPENDIX

Complete Tables of Analytical Results from the Mineral Absorption Experiment

TABLE 1.—MINERAL INTAKE EXPERIMENT—OTTAWA, 1935 (CIGAR TOBACCO)

Lab. No.	Description of Sample	Date taken	Dry Matter Basis (Sand-free, Moisture-free)								
			Ash	$Fe_2O_3 + Al_2O_3$	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
M 3	Five bottom leaves—Seedlings-leaf tissue	June 10	21·02	1·55	2·54	1·01	·86	9·11	·71	1·21	·013
M 4	" " " Early growth	July 2	16·51	3·33	3·82	·69	·42	5·28	·55	·22	·021
M 7	" " " Mid-vegetative	July 23	25·48	1·26	6·02	·93	·41	7·76	·93	·42	·019
M11	" " " Early bud	Aug. 1	26·89	·67	6·69	1·21	·38	8·52	1·06	·48	·016
M15	" " " Early bloom	Aug. 8	25·58	1·14	6·61	1·10	·35	7·97	·91	·36	·016
M20	" " " Harvesting	Aug. 24	27·27	·38	5·82	1·01	·33	10·23	·66	·23	·007
M 5	Five middle leaves—Early growth	July 2	14·98	3·88	2·99	·84	·59	2·94	·75	·32	·022
M 8	" " " Mid-vegetative	July 23	19·53	1·66	3·67	·80	·85	8·34	·91	·47	·018
M12	" " " Early bud	Aug. 1	20·74	·52	4·46	·90	·53	8·21	·89	·41	·010
M16	" " " Early bloom	Aug. 8	20·61	·64	4·51	·95	·43	4·54	·83	·34	·012
M21	" " " Harvesting	Aug. 24	25·03	·33	4·64	1·12	·47	10·07	·87	·29	·010
M 9	Five top leaves—Mid-vegetative	July 23	16·49	1·92	1·79	·79	1·38	7·41	·94	·54	·018
M13	" " " Early bud	Aug. 1	15·66	·47	2·56	·79	·90	6·49	·87	·40	·012
M17	" " " Early bloom	Aug. 8	16·10	1·02	3·01	·74	·56	6·10	·29	·34	·008
M22	" " " Harvesting	Aug. 24	20·69	·30	3·75	·91	·57	8·43	·89	·37	·009
M18	Tops—Early bloom	Aug. 8	11·36	2·06	·85	·58	1·22	5·18	·74	·47	·007
M 2	Stalks—Seedlings	June 10	27·01	·87	1·61	·59	·83	14·48	·58	2·01	·018
M 6	" Early growth	July 2	17·66	2·39	2·11	·48	·36	7·96	·60	·39	·013
M10	" Mid-vegetative	July 23	20·49	·94	1·50	·59	·74	11·88	·66	·88	·009
M14	" Early bud	Aug. 1	15·64	·38	1·38	·42	·60	8·26	·59	·72	·005
M19	" Early bloom	Aug. 8	11·82	·81	1·11	·45	·46	5·98	·44	·59	·004
M23	" Harvesting	Aug. 24	11·68	·42	1·15	·40	·41	6·06	·47	·35	·002

TABLE 2.—MINERAL INTAKE EXPERIMENT—OTTAWA, 1935 (CIGAR TOBACCO)

Lab. No.	Description of Sample	Date taken	Percentage of Ash							
			$Fe_2O_3 + Al_2O_3$	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
M 3	Five bottom leaves—Seedlings-leaf tissue	June 10	7·38	12·07	4·81	4·08	43·35	3·38	5·75	·062
M 4	" " " Early growth	July 2	20·18	23·14	4·18	2·54	32·00	3·33	1·33	·129
M 7	" " " Mid-vegetative	July 23	4·94	23·61	3·65	1·61	30·43	4·01	1·65	·075
M11	" " " Early bud	Aug. 1	2·49	24·86	4·50	1·41	31·69	3·94	1·77	·060
M15	" " " Early bloom	Aug. 8	4·46	25·84	4·30	1·37	31·18	3·56	1·41	·060
M20	" " " Harvesting	Aug. 24	1·40	21·33	3·70	1·21	37·51	2·42	·84	·026
M 5	Five middle leaves—Early growth	July 2	25·92	19·95	5·61	3·94	19·63	5·01	2·14	·147
M 8	" " " Mid-vegetative	July 23	8·50	18·78	4·09	4·35	42·65	4·66	2·41	·092
M12	" " " Early bud	Aug. 1	2·51	23·64	4·34	2·56	39·58	4·28	1·98	·048
M16	" " " Early bloom	Aug. 8	3·10	21·90	4·61	2·08	36·57	4·03	1·65	·058
M21	" " " Harvesting	Aug. 24	1·32	18·53	4·48	1·88	40·23	3·48	1·16	·040
M 9	Five top leaves—Mid-vegetative	July 23	11·63	10·85	4·78	8·37	44·90	5·70	3·27	·109
M13	" " " Early bud	Aug. 1	3·00	16·66	5·05	5·40	41·45	5·56	2·56	·077
M17	" " " Early bloom	Aug. 8	6·34	18·70	4·60	3·48	37·88	1·80	2·11	·050
M22	" " " Harvesting	Aug. 24	1·45	18·11	4·39	2·76	40·68	4·30	1·79	·043
M18	Tops—Early bloom	Aug. 8	18·13	7·48	5·11	10·74	45·60	6·52	4·13	·062
M 2	Stalks—Seedlings	June 10	3·22	5·96	2·18	3·07	53·60	2·15	7·45	·067
M 6	" Early growth	July 2	13·53	11·94	2·72	2·04	45·10	3·40	2·21	·074
M10	" Mid-vegetative	July 23	4·58	7·32	2·88	3·61	57·90	3·22	4·29	·044
M14	" Early bud	Aug. 1	2·43	8·83	2·68	3·84	52·80	3·77	4·61	·032
M19	" Early bloom	Aug. 8	6·85	9·39	3·81	3·89	50·62	3·72	4·99	·034
M23	" Harvesting	Aug. 24	3·60	9·85	3·43	3·51	51·85	4·02	3·00	·017

TABLE 3.—MINERAL INTAKE EXPERIMENT—OTTAWA, 1935 (CIGAR TOBACCO)

Lab. No.	Description of Sample	Date taken	Green Matter Basis									
			Moisture	Ash	Fe_2O_3 + Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
M 3	Five bottom leaves—Seedlings-leaf tissue......	June 10	91·8	1·724	·127	·208	·083	·071	·748	·058	·099	·0011
M 4	" " " Early growth...........	July 2	79·4	3·401	·686	·787	·142	·087	1·088	·113	·045	·0043
M 7	" " " Mid-vegetative..........	July 23	90·2	2·497	·124	·590	·091	·040	·760	·091	·041	·0019
M11	" " " Early bud...............	Aug. 1	89·8	2·743	·068	·682	·123	·039	·868	·108	·049	·0016
M15	" " " Early bloom............	Aug. 8	90·4	2·456	·109	·634	·106	·034	·765	·087	·035	·0015
M20	" " " Harvesting.............	Aug. 24	91·0	2·454	·034	·524	·091	·030	·921	·059	·021	·0006
M 5	Five middle leaves—Early growth...........	July 2	80·5	2·921	·757	·583	·164	·115	·573	·146	·062	·0043
M 8	" " " Mid-vegetative..........	July 23	89·8	1·992	·169	·374	·082	·087	·850	·093	·048	·0018
M12	" " " Early bud...............	Aug. 1	88·8	2·323	·058	·499	·101	·059	·919	·100	·046	·0011
M16	" " " Early bloom............	Aug. 8	88·2	2·432	·076	·532	·112	·051	·889	·098	·040	·0014
M21	" " " Harvesting.............	Aug. 24	90·4	2·403	·032	·446	·108	·045	·966	·084	·028	·0010
M 9	Five top leaves—Mid-vegetative.............	July 23	88·8	1·847	·215	·200	·088	·155	·830	·105	·060	·0020
M13	" " " Early bud.................	Aug. 1	87·6	1·942	·058	·317	·098	·112	·804	·108	·050	·0015
M17	" " " Early bloom................	Aug. 8	86·6	2·158	·137	·403	·099	·075	·817	·039	·046	·0011
M22	" " " Harvesting.................	Aug. 24	86·8	2·938	·043	·532	·129	·081	1·197	·126	·053	·0013
M18	Tops—Early bloom.........................	Aug. 8	88·2	1·341	·243	·100	·068	·144	·611	·087	·055	·0008
M 2	Stalks —Seedlings...........................	June 10	95·8	1·134	·037	·068	·025	·035	·608	·024	·084	·0008
M 6	" Early growth.......................	July 2	87·8	2·155	·292	·257	·059	·044	·971	·073	·048	·0016
M10	" Mid-vegetative.....................	July 23	93·4	1·352	·062	·099	·039	·049	·784	·044	·058	·0006
M14	" Early bud..........................	Aug. 1	91·8	1·282	·031	·113	·034	·049	·677	·048	·059	·0004
M19	" Early bloom........................	Aug. 8	90·2	1·159	·079	·109	·044	·045	·586	·043	·058	·0004
M23	" Harvesting.........................	Aug. 24	88·8	1·309	·047	·129	·045	·046	·679	·053	·039	·0002

TABLE 4.—MINERAL INTAKE EXPERIMENT—OTTAWA, 1935 (CIGAR TOBACCO)

Lab. No.	Description of Sample	Date taken	Absolute Weight per Plant—Grams											
			Green weight	Moisture	Dry matter	Ash	$Fe_2O_3 + Al_2O_3$	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
M 3	Five bottom leaves—Seedlings-leaf tissue	June 10	1·921	1·7593	·1617	·0331	·0024	·0040	·0016	·0014	·0144	·0011	·0019	·000021
M 4	" " " Early growth	July 2	6·726	5·3410	1·3850	·2288	·0461	·0542	·0096	·0059	·0732	·0076	·0030	·000289
M 7	" " " Mid-vegetative	July 23	99·400	89·6588	9·7412	2·4820	·1231	·5865	·0905	·0398	·7554	·0905	·0408	·001890
M11	" " " Early bud	Aug. 1	162·600	146·0148	16·5852	4·4601	·1106	1·1089	·2000	·0634	1·4114	·1756	·0797	·002600
M15	" " " Early bloom	Aug. 8	182·700	165·1608	17·5392	4·4871	·1991	1·1583	1·937	·0621	1·3977	·1589	·0639	·002740
M20	" " " Harvesting	Aug. 24	233·200	212·2120	20·9880	5·7227	·0793	1·2220	·2122	·0700	2·1478	·1376	·0490	·001400
M 5	Five middle leaves—Early growth	July 2	·687	·5531	·1339	·0201	·0052	·0040	·0011	·0008	·0039	·0010	·0004	·000030
M 8	" " " Mid-vegetative	July 23	109·800	98·6004	11·1996	2·1872	·1853	·4107	·0900	·0955	·9333	·1021	·0527	·001980
M12	" " " Early bud	Aug. 1	223·400	198·3792	25·0208	5·1896	·1296	1·1148	·2256	·1318	2·0530	·2234	·1028	·002460
M16	" " " Early bloom	Aug. 8	289·700	255·5154	34·1846	7·0455	·2202	1·5412	·3245	·1477	2·5754	·2839	·1159	·004060
M21	" " " Harvesting	Aug. 24	331·000	299·2240	31·7760	7·9539	·1059	1·4763	·3575	·1490	3·1975	·2780	·0927	·003310
M 9	Five top leaves—Mid-vegetative	July 23	19·900	17·6712	2·2288	·3676	·0428	·0398	·0175	·0380	·1652	·0209	·0119	·000400
M13	" " " Early bud	Aug. 1	136·600	119·6616	16·9384	2·6528	·0792	·4330	·1339	·1530	1·0983	·1475	·0683	·002490
M17	" " " Early bloom	Aug. 8	279·500	242·0470	37·4530	6·0316	·3829	1·1264	·2767	·2096	2·2835	·1090	·1286	·003070
M22	" " " Harvesting	Aug. 24	336·300	291·9084	44·3916	9·8805	·1446	1·7891	·4338	·2724	4·0255	·4237	·1782	·004370
M18	Tops—Early bloom	Aug. 8	86·800	76·5576	10·2424	1·1640	·2109	·0868	·0590	·1250	·5303	·0755	·0477	·000690
M 2	Stalks—Seedlings	June 10	2·026	1·9415	·0845	·0230	·0008	·0014	·0005	·0007	·0123	·0005	·0017	·000016
M 6	" Early growth	July 2	2·466	2·1650	·3010	·0531	·0072	·0063	·0015	·0011	·0240	·0018	·0012	·000040
M10	" Mid-vegetative	July 23	58·700	54·8258	3·8742	·7936	·0364	·0581	·0229	·0288	·4602	·0258	·0340	·000350
M14	" Early bud	Aug. 1	265·600	243·8208	21·7792	3·4050	·0823	·3001	·0903	·1301	1·7981	·1275	·1567	·001060
M19	" Early bloom	Aug. 8	404·100	364·4982	39·6018	4·6835	·3192	·4405	·1778	·1818	2·3680	·1738	·2344	·001620
M23	" Harvesting	Aug. 24	483·200	429·0816	54·1184	6·3251	·2271	·6233	·2174	·2223	3·2809	·2561	·1884	·000970
	Total plant—Seedlings	June 10	3·947	3·6710	·2760	·0561	·0031	·0058	·0025	·0025	·0345	·0018	·0045	·000023
	" " Early growth	July 2	9·880	8·0591	1·8209	·3020	·0585	·0645	·0122	·0078	·1011	·0104	·0046	·000359
	" " Mid-vegetative	July 23	287·800	260·7562	27·0438	5·8304	·3879	1·0951	·2209	·1949	2·3141	·2393	·1394	·004620
	" " Early bud	Aug. 1	788·200	707·8770	80·3230	15·7075	·4017	2·9568	·6498	·4783	6·3608	·6740	·4075	·008610
	" " Early bloom	Aug. 8	1,242·800	1,103·7790	139·0210	23·4117	1·3323	4·3532	1·0317	·7262	9·1549	·8011	·5905	·012180
	" " Harvesting	Aug. 24	1,383·700	1,232·4260	151·2740	29·8822	·5569	5·1107	1·2209	·7137	12·6517	1·0954	·5083	·010050

TABLE 5.—MINERAL-INTAKE EXPERIMENT—OTTAWA, 1936 (CIGAR TOBACCO)

Lab. No.	Description of Sample	Date of Sampling	Dry-matter Basis (sand-free, moisture-free)—Percentage									
			Ash	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
MO- 1	Bottom leaves—Seedling stage	June 10	24·19	·083	·386	2·96	1·26	·62	4·62	·98	1·38	·012
MO- 3	" Early growth	July 13	22·68	·235	1·249	5·44	1·17	·29	5·13	·99	·49	·032
MO- 6	" Intermediate	July 22	29·42	·198	·726	6·60	1·18	·38	5·45	1·17	·54	·024
MO- 9	" Mid-vegetative	July 28	27·85	·210	·562	6·43	1·04	·29	5·19	1·13	·41	·043
MO-13	" Late vegetative	Aug. 5	25·20	·113	·462	6·59	·68	·41	8·39	·97	·31	·048
MO-18	" Early bud	Aug. 8	25·56	·111	·354	7·28	·65	·34	8·13	1·08	·22	·039
MO-23	" Early bloom	Aug. 11	27·16	·128	·302	7·78	·70	·32	8·76	·78	·22	·060
MO-28	" Late bloom	Aug. 19	25·86	·095	·345	6·97	·70	·33	8·62	·98	·15	·032
MO-37	" Harvest stage	Aug. 27	26·26	·075	·378	7·21	·64	·41	6·50	·74	·47	·034
MO-33	" Late bloom (topped)	Aug. 19	25·16	·081	·301	7·58	·93	·36	7·22	·85	·25	·029
MO-42	" Harvest (topped)	Aug. 27	24·85	·068	·328	7·13	·64	·34	6·67	·64	·25	·032
MO- 4	Middle leaves—Early growth	July 13	21·18	·506	2·630	2·64	1·34	·68	6·35	·97	·72	·030
MO- 7	" Intermediate	July 22	21·92	·189	·664	2·92	·10	·71	5·15	·79	·59	·019
MO-10	" Mid-vegetative	July 28	24·41	·193	·493	4·48	·77	·48	5·38	1·19	·55	·033
MO-14	" Late vegetative	Aug. 5	19·69	·072	·198	4·14	·57	·54	8·39	·95	·28	·027
MO-19	" Early bud	Aug. 8	21·50	·068	·254	4·73	·56	·42	8·52	·91	·25	·027
MO-24	" Early bloom	Aug. 11	21·88	·080	·211	5·20	·56	·33	8·49	·88	·22	·035
MO-29	" Late bloom	Aug. 19	20·95	·045	·273	4·80	·59	·41	8·47	1·04	·15	·008
MO-38	" Harvest	Aug. 27	22·04	·054	·192	5·61	·57	·47	7·15	·74	·25	·028
MO-34	" Late bloom (topped)	Aug. 19	21·85	·060	·171	6·08	·81	·50	6·85	·76	·25	·023
MO-43	" Harvest (topped)	Aug. 27	21·38	·058	·206	5·37	·58	·43	6·67	·67	·25	·027
MO-11	Top leaves—Mid-vegetative	July 28	14·55	·096	·200	2·09	·74	·83	4·94	·92	·56	·017
MO-15	" Late vegetative	Aug. 5	15·94	·056	·117	2·71	·58	·93	7·62	1·21	·37	·017
MO-20	" Early bud	Aug. 8	17·06	·060	·261	3·29	·52	·68	8·07	1·00	·30	·019
MO-25	" Early bloom	Aug. 11	19·07	·059	·350	3·87	·58	·50	7·59	1·09	·28	·017
MO-30	" Late bloom	Aug. 19	18·06	·042	·344	3·80	·57	·51	7·22	1·12	·22	·017
MO-39	" Harvest	Aug. 27	19·53	·045	·182	4·32	·55	·53	6·53	·76	·25	·025
MO-35	" Late bloom (topped)	Aug. 19	18·65	·037	·170	4·62	·75	·60	6·60	·94	·37	·020
MO-44	" Harvest (topped)	Aug. 27	17·89	·037	·134	4·17	·58	·52	6·37	·86	·34	·025
MO-16	Tops—Late vegetative	Aug. 5	14·11	·129	·168	2·71	·62	1·83	8·71	1·54	·48	·022
MO-21	" Early bud	Aug. 8	13·93	·061	·133	2·00	·65	1·20	6·77	1·01	·30	·015
MO-26	" Early bloom	Aug. 11	14·60	·061	·370	2·56	·64	·95	6·17	1·09	·28	·020
MO-31	" Late bloom	Aug. 19	13·03	·088	·260	2·03	·52	·87	5·80	·94	·47	·011
MO-40	" Harvest	Aug. 27	12·76	·069	·216	2·30	·52	·94	5·74	·78	·34	·013
MO- 2	Stalks—Seedling stage	June 10	26·02	·102	·723	3·08	·91	·52	10·37	·92	2·74	·013
MO- 5	" Early growth	July 13	20·59	·506	1·302	3·17	·98	·40	8·88	1·99	·63	·007
MO- 8	" Intermediate	July 22	22·54	·200	·900	1·97	·77	·54	5·13	·83	·80	·011
MO-12	" Mid-vegetative	July 28	21·52	·148	·402	1·93	·57	·46	4·75	·69	·89	·007
MO-17	" Late vegetative	Aug. 5	16·86	·086	·041	1·89	·36	·54	8·88	·68	·52	·007
MO-22	" Early bud	Aug. 8	15·64	·057	·156	1·83	·28	·50	8·35	·70	·47	·008
MO-27	" Early bloom	Aug. 11	14·34	·050	·216	1·71	·34	·45	7·51	·72	·47	·005
MO-32	" Late bloom	Aug. 19	12·81	·036	·167	1·62	·31	·34	6·21	·73	·33	·006
MO-41	" Harvest	Aug. 27	13·68	·057	·173	1·83	·36	·42	6·63	·39	·43	·010
MO-36	" Late bloom (topped)	Aug. 19	11·43	·038	·133	1·69	·38	·40	5·21	·33	·55	·008
MO-45	" Harvest (topped)	Aug. 27	12·56	·075	·156	1·92	·38	·42	5·77	·31	·46	·009

TABLE 6.—MINERAL-INTAKE EXPERIMENT—OTTAWA, 1936 (CIGAR TOBACCO)

Lab. No.	Description of Sample	Date of Sampling	Percentage of Ash								
			Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
MO- 1	Bottom leaves—Seedling stage	June 10	·34	1·60	12·24	5·21	2·56	19·10	4·05	5·70	·05
MO- 3	" Early growth	July 13	1·04	5·51	23·99	5·16	1·28	22·62	4·37	2·16	·14
MO- 6	" Intermediate	July 22	·67	2·47	22·43	4·01	1·29	18·52	3·98	1·84	·08
MO- 9	" Mid-vegetative	July 28	·75	2·02	23·09	3·73	1·04	18·64	4·06	1·47	·15
MO-13	" Late vegetative	Aug. 5	·45	1·83	26·15	2·70	1·63	33·29	3·85	1·23	·19
MO-18	" Early bud	Aug. 8	·43	1·38	28·48	2·54	1·33	31·81	4·23	·86	·15
MO-23	" Early bloom	Aug. 11	·47	1·11	28·65	2·58	1·18	32·25	2·87	·81	·22
MO-28	" Late bloom	Aug. 19	·37	1·33	26·95	2·71	1·28	33·33	3·79	·58	·12
MO-37	" Harvest	Aug. 27	·29	1·44	27·46	2·44	1·56	24·75	2·82	1·79	·13
MO-33	" Late bloom (topped)	Aug. 19	·32	1·20	30·13	3·70	1·43	28·70	3·38	·99	·12
MO-42	" Harvest (topped)	Aug. 27	·27	1·32	28·69	2·58	1·37	26·84	2·58	1·01	·13
MO- 4	Middle leaves—Early growth	July 13	2·39	12·42	12·46	6·33	3·21	29·98	4·58	3·40	·14
MO- 7	" Intermediate	July 22	·86	3·03	13·32	·46	3·24	23·49	3·60	2·69	·09
MO-10	" Mid-vegetative	July 28	·79	2·03	18·35	3·15	1·97	22·04	4·88	2·25	·14
MO-14	" Late vegetative	Aug. 5	·37	1·01	21·03	2·89	2·74	42·61	4·82	1·42	·14
MO-19	" Early bud	Aug. 8	·32	1·18	22·00	2·60	1·95	39·63	4·23	1·16	·13
MO-24	" Early bloom	Aug. 11	·37	·96	23·77	2·56	1·51	38·80	4·02	1·01	·16
MO-29	" Late bloom	Aug. 19	·21	1·30	22·91	2·82	1·96	40·43	4·96	·72	·04
MO-38	" Harvest	Aug. 27	·25	·87	25·45	2·59	2·13	32·44	3·36	1·13	·13
MO-34	" Late bloom (topped)	Aug. 19	·27	·78	27·83	3·71	2·29	31·35	3·48	1·14	·11
MO-43	" Harvest (topped)	Aug. 27	·27	·96	25·12	2·71	2·01	31·20	3·13	1·17	·13
MO-11	Top leaves—Mid-vegetative	July 28	·66	1·37	14·36	5·09	5·70	33·95	6·32	3·85	·12
MO-15	" Late vegetative	Aug. 5	·35	·73	17·00	3·64	5·83	47·80	7·59	2·32	·11
MO-20	" Early bud	Aug. 8	·35	1·53	19·28	3·05	3·99	47·30	5·86	1·76	·11
MO-25	" Early bloom	Aug. 11	·31	1·84	20·29	3·04	2·62	39·80	5·72	1·47	·09
MO-30	" Late bloom	Aug. 19	·23	1·90	21·04	3·16	2·82	39·98	6·20	1·22	·09
MO-39	" Harvest	Aug. 27	·23	·93	22·12	2·82	2·71	33·44	3·89	1·28	·13
MO-35	" Late bloom (topped)	Aug. 19	·20	·91	23·51	4·02	3·22	35·39	5·04	1·98	·11
MO-44	" Harvest (topped)	Aug. 27	·21	·75	23·31	3·24	2·91	35·61	4·81	1·90	·14
MO-16	Tops—Late vegetative	Aug. 5	·91	1·19	19·21	4·39	12·97	61·73	10·91	3·40	·16
MO-21	" Early bud	Aug. 8	·44	·95	14·36	4·67	8·61	48·60	7·25	2·15	·11
MO-26	" Early bloom	Aug. 11	·42	2·53	17·53	4·38	6·51	42·26	7·47	1·92	·14
MO-31	" Late bloom	Aug. 19	·68	2·00	15·58	3·99	6·68	44·51	7·21	3·61	·08
MO-40	" Harvest	Aug. 27	·54	1·69	18·03	4·08	7·37	44·98	6·11	2·66	·10
MO- 2	Stalks—Seedling	June 10	·39	2·78	11·84	3·50	2·00	39·85	3·54	10·53	·05
MO- 5	" Early growth	July 13	2·46	6·32	15·40	4·76	1·94	43·13	9·66	3·06	·03
MO- 8	" Intermediate	July 22	·89	3·99	8·74	3·42	2·40	22·76	3·68	3·55	·05
MO-12	" Mid-vegetative	July 28	·69	1·87	8·97	2·65	2·14	22·07	3·21	4·14	·03
MO-17	" Late vegetative	Aug. 5	·51	·24	11·21	2·14	3·20	52·67	4·03	3·08	·04
MO-22	" Early bud	Aug. 8	·36	1·00	11·70	1·79	3·20	53·39	4·48	3·01	·05
MO-27	" Early bloom	Aug. 11	·35	1·51	11·92	2·37	3·14	52·37	5·02	3·28	·03
MO-32	" Late bloom	Aug. 19	·28	1·30	12·65	2·42	2·65	48·48	5·70	2·58	·05
MO-41	" Harvest	Aug. 27	·42	1·26	13·38	2·63	3·07	48·46	2·85	3·14	·07
MO-36	" Late bloom (topped)	Aug. 19	·33	1·16	14·79	3·32	3·50	45·58	2·89	4·81	·07
MO-45	" Harvest (topped)	Aug. 27	·59	1·23	15·17	3·00	3·32	45·58	2·45	3·63	·07

TABLE 7.—MINERAL-INTAKE EXPERIMENT—OTTAWA, 1936 (CIGAR TOBACCO)

Lab. No.	Description of Sample	Date of Sampling	Green Matter Basis—Percentage											
			Moisture	Dry Matter	Ash	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
MO- 1	Bottom Leaves—Seedling stage	June 10	94·4	5·6	1·355	·005	·022	·166	·071	·035	·259	·055	·077	·0007
MO- 3	" Early growth	July 13	89·4	10·6	2·404	·025	·132	·577	·124	·031	·544	·105	·052	·0034
MO- 6	" Intermediate	July 22	87·0	13·0	3·825	·026	·094	·858	·153	·049	·709	·152	·070	·0031
MO- 9	" Mid-vegetative	July 28	87·4	12·6	3·509	·026	·071	·810	·131	·037	·654	·142	·052	·0054
MO-13	" Late vegetative	Aug. 5	89·2	10·8	2·722	·012	·050	·712	·073	·044	·906	·105	·033	·0052
MO-18	" Early bud	Aug. 8	88·4	11·6	2·965	·013	·041	·844	·075	·039	·943	·125	·026	·0045
MO-23	" Early bloom	Aug. 11	87·8	12·2	3·314	·016	·037	·949	·085	·039	1·069	·095	·027	·0073
MO-28	" Late bloom	Aug. 19	87·4	12·6	3·258	·012	·043	·878	·088	·042	1·086	·123	·019	·0040
MO-37	" Harvest	Aug. 27	87·2	12·8	3·361	·010	·048	·923	·082	·052	·832	·095	·060	·0044
MO-33	" Late bloom (topped)	Aug. 19	88·2	11·8	2·969	·010	·036	·894	·110	·042	·852	·100	·030	·0034
MO-42	" Harvest (topped)	Aug. 27	88·6	11·4	2·833	·008	·037	·813	·073	·039	·760	·073	·029	·0036
MO- 4	Middle leaves—Early growth	July 13	87·1	12·9	2·732	·065	·339	·341	·173	·088	·819	·125	·093	·0039
MO- 7	" Intermediate	July 22	86·0	14·0	3·069	·026	·093	·409	·014	·099	·721	·111	·083	·0027
MO-10	" Mid-vegetative	July 28	85·6	14·4	3·515	·028	·074	·645	·111	·069	·775	·171	·079	·0048
MO-14	" Late vegetative	Aug. 5	88·8	11·2	2·205	·008	·022	·464	·064	·060	·940	·106	·031	·0030
MO-19	" Early bud	Aug. 8	89·2	10·8	2·322	·007	·027	·511	·060	·045	·920	·098	·027	·0029
MO-24	" Early bloom	Aug. 11	87·6	12·4	2·713	·010	·026	·645	·069	·041	1·053	·109	·027	·0043
MO-29	" Late bloom	Aug. 19	86·2	13·8	2·891	·006	·038	·662	·081	·057	1·169	·144	·021	·0011
MO-38	" Harvest	Aug. 27	86·6	13·4	2·953	·007	·026	·752	·076	·063	·958	·099	·034	·0038
MO-34	" Late bloom (topped)	Aug. 19	87·2	12·8	2·797	·008	·022	·778	·104	·064	·877	·097	·032	·0029
MO-43	" Harvest (topped)	Aug. 27	87·4	12·6	2·694	·007	·026	·677	·073	·054	·840	·084	·032	·0034
MO-11	Top leaves—Mid-vegetative	July 28	86·6	13·4	1·950	·013	·027	·280	·099	·111	·662	·123	·075	·0023
MO-15	" Late vegetative	Aug. 5	89·2	10·8	1·722	·006	·013	·293	·063	·100	·823	·131	·040	·0018
MO-20	" Early bud	Aug. 8	89·0	11·0	1·877	·007	·029	·362	·057	·075	·888	·110	·033	·0021
MO-25	" Early bloom	Aug. 11	87·2	12·8	2·441	·008	·045	·495	·074	·064	·972	·140	·036	·0022
MO-30	" Late bloom	Aug. 19	84·8	15·2	2·745	·006	·052	·578	·087	·078	1·097	·170	·033	·0026
MO-39	" Harvest	Aug. 27	86·2	13·8	2·890	·007	·027	·639	·081	·078	·966	·112	·037	·0037
MO-35	" Late bloom (topped)	Aug. 19	87·0	13·0	2·425	·005	·022	·601	·098	·078	·858	·122	·048	·0026
MO-44	" Harvest (topped)	Aug. 27	86·0	14·0	2·505	·005	·019	·584	·081	·073	·892	·120	·048	·0035
MO-16	Tops—Late vegetative	Aug. 5	88·8	11·2	1·580	·014	·019	·304	·069	·205	·976	·172	·054	·0025
MO-21	" Early bud	Aug. 8	88·8	11·2	1·560	·007	·015	·224	·073	·134	·758	·113	·034	·0017
MO-26	" Early bloom	Aug. 11	87·6	12·4	1·810	·008	·046	·317	·079	·118	·765	·135	·035	·0025
MO-31	" Late bloom	Aug. 19	86·6	13·4	1·746	·012	·035	·272	·070	·117	·777	·126	·063	·0015
MO-40	" Harvest	Aug. 27	86·0	14·0	1·786	·010	·030	·322	·073	·132	·804	·109	·048	·0018
MO- 2	Stalks—Seedling	June 10	96·0	4·0	1·041	·004	·029	·123	·036	·021	·415	·037	·110	·0005
MO- 5	" Early growth	July 13	88·9	11·1	2·285	·056	·145	·352	·109	·044	·986	·221	·070	·0008
MO- 8	" Intermediate	July 22	92·8	7·2	1·623	·014	·065	·142	·055	·039	·369	·060	·058	·0008
MO-12	" Mid-vegetative	July 28	91·0	9·0	1·937	·013	·036	·174	·051	·041	·428	·062	·080	·0006
MO-17	" Late vegetative	Aug. 5	92·4	7·6	1·281	·007	·003	·144	·027	·041	·675	·052	·040	·0005
MO-22	" Early bud	Aug. 8	91·8	8·2	1·282	·005	·013	·150	·023	·041	·685	·057	·039	·0007
MO-27	" Early bloom	Aug. 11	91·4	8·6	1·233	·004	·019	·147	·029	·039	·646	·062	·040	·0004
MO-32	" Late bloom	Aug. 19	93·8	6·2	·794	·002	·010	·100	·019	·021	·385	·045	·020	·0004
MO-41	" Harvest	Aug. 27	88·0	12·0	1·642	·007	·021	·220	·043	·050	·796	·047	·052	·0012
MO-36	" Late bloom (topped)	Aug. 19	91·3	8·7	·994	·003	·012	·147	·033	·035	·453	·029	·048	·0007
MO-45	" Harvest (topped)	Aug. 27	89·0	11·0	1·393	·008	·017	·211	·042	·046	·635	·034	·051	·0010

TABLE 8.—MINERAL-INTAKE EXPERIMENT—OTTAWA, 1936 (CIGAR TOBACCO)

Lab. No.	Description of Sample	Date of Sampling	Absolute Weight per Plant in Grams												
			Total green weight	Moisture	Dry matter	Ash	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
MO- 1	Bottom leaves—Seedling stage...	June 10	3·88	3·6627	·2173	·0526	·0002	·0009	·0064	·0028	·0014	·0100	·0021	·0030	·000027
MO- 3	" Early growth....	July 13	9·76	8·7254	1·0346	·2346	·0024	·0129	·0563	·0121	·0030	·0531	·0102	·0051	·000332
MO- 6	" Intermediate.....	July 22	42·0	36·5400	5·4600	1·6065	·0109	·0395	·3604	·0643	·0206	·2978	·0638	·0294	·001302
MO- 9	" Mid-vegetative..	July 28	43·8	38·2812	5·5188	1·5369	·0114	·0311	·3548	·0574	·0162	·2865	·0622	·0228	·002365
MO-13	" Late vegetative..	Aug. 5	123·2	109·8944	13·3056	3·3535	·0148	·0616	·8772	·0899	·0542	1·1162	·1294	·0407	·006406
MO-18	" Early bud.......	Aug. 8	126·5	111·8260	14·6740	3·7507	·0164	·0519	1·0677	·0949	·0493	1·1929	·1581	·0329	·005693
MO-23	" Early bloom.....	Aug. 11	157·7	138·4606	19·2394	5·2262	·0252	·0583	1·4966	·1340	·0615	1·6858	·1498	·0426	·011512
MO-28	" Late bloom......	Aug. 19	243·5	212·8190	30·6810	7·9332	·0292	·1047	2·1379	·2143	·1023	2·6444	·2995	·0463	·009740
MO-37	" Harvest.........	Aug. 27	282·4	246·2528	36·1472	9·4915	·0282	·1356	2·6066	·2316	·1468	2·3496	·2683	·1694	·012426
MO-33	" Late bloom (topped).......	Aug. 19	213·7	188·4834	25·2166	6·3448	·0214	·0769	1·9105	·2351	·0898	1·8207	·2137	·0641	·007266
MO-42	" Harvest (topped)	Aug. 27	245·1	217·1586	27·9414	6·9437	·0196	·0907	1·9927	·1789	·0956	1·8628	·1789	·0711	·008824
MO- 4	Middle leaves—Early growth....	July 13	2·41	2·0991	·3109	·0658	·0016	·0082	·0082	·0042	·0021	·0197	·0030	·0022	·000094
MO- 7	" Intermediate....	July 22	34·6	29·7560	4·8440	1·0619	·0090	·0322	·1415	·0048	·0343	·2495	·0384	·0287	·000934
MO-10	" Mid-vegetative..	July 28	88·8	76·0128	12·7872	3·1213	·0249	·0630	·5728	·0986	·0613	·6882	·1518	·0702	·004262
MO-14	" Late vegetative..	Aug. 5	147·4	130·8912	16·5088	3·2502	·0118	·0324	·6839	·0943	·0884	1·3856	·1562	·0457	·004422
MO-19	" Early bud.......	Aug. 8	171·1	152·6212	18·4788	3·9729	·0120	·0462	·8743	·1027	·0770	1·5741	·1677	·0462	·004962
MO-24	" Early bloom.....	Aug. 11	194·5	170·3820	24·1180	5·2768	·0195	·0506	1·2545	·1342	·0797	2·0481	·2120	·0525	·008364
MO-29	" Late bloom......	Aug. 19	246·1	212·1382	33·9618	7·1148	·0148	·0935	1·6292	·1993	·1403	2·8769	·3544	·0517	·002707
MO-38	" Harvest.........	Aug. 27	304·7	263·8702	40·8298	8·9978	·0213	·0792	2·2913	·2316	·1920	2·9190	·3017	·1036	·011579
MO-34	" Late bloom (topped).......	Aug. 19	244·6	213·2912	31·3088	6·8415	·0196	·0538	1·9030	·2544	·1565	2·1451	·3273	·0783	·007093
MO-43	" Harvest (topped)	Aug. 27	305·9	267·3566	38·5434	8·2409	·0214	·0795	2·0709	·2233	·1652	2·5696	·2570	·0979	·010401
MO-11	Top leaves—Mid-vegetative.....	July 28	25·1	21·7366	3·3634	·4895	·0033	·0068	·0703	·0248	·0279	·1662	·0309	·0188	·000577
MO-15	" Late vegetative.....	Aug. 5	64·9	57·8908	7·0092	1·1176	·0039	·0084	·1902	·0409	·0649	·5341	·0850	·0260	·001168
MO-20	" Early bud..........	Aug. 8	99·2	88·2880	10·9120	1·8620	·0069	·0288	·3591	·0565	·0744	·8809	·1091	·0327	·002083
MO-25	" Early bloom........	Aug. 11	158·7	138·3864	20·3136	3·8739	·0127	·0714	·7856	·1174	·1016	1·5426	·2222	·0571	·003491
MO-30	" Late bloom.........	Aug. 19	200·2	169·7696	30·4304	5·4955	·0120	·1041	1·1572	·1742	·1562	2·1962	·3403	·0661	·005205
MO-39	" Harvest...........	Aug. 27	280·5	241·7910	38·7090	8·1065	·0196	·0757	1·7924	·2272	·2188	2·7096	·3142	·1038	·010379
MO-35	" Late bloom (topped)	Aug. 19	208·6	181·4820	27·1180	5·0586	·0104	·0459	1·2537	·2044	·1627	1·7898	·2545	·1001	·005424
MO-44	" Harvest (topped)...	Aug. 27	307·2	264·1920	43·0080	7·6954	·0154	·0584	1·7940	·2488	·2243	2·7402	·3686	·1475	·010752

TABLE 8.—MINERAL-INTAKE EXPERIMENT—OTTAWA, 1936 (CIGAR TOBACCO)—*Concluded*

Lab. No.	Description of Sample	Date of Sampling	Absolute Weight per Plant in Grams												
			Total green weight	Moisture	Dry matter	Ash	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
MO-16	Tops—Late vegetative	Aug. 5	8·3	7·3704	·9296	·1311	·0012	·0016	·0252	·0057	·0170	·0810	·0143	·0045	·000208
MO-21	" Early bud	Aug. 8	33·5	29·7480	3·7520	·5226	·0023	·0050	·0750	·0245	·0449	·2539	·0379	·0114	·000570
MO-26	" Early bloom	Aug. 11	109·1	95·5716	13·5284	1·9747	·0087	·0502	·3458	·0862	·1287	·8346	·1473	·0382	·002728
MO-31	" Late bloom	Aug. 19	161·4	139·7724	21·6276	2·8180	·0194	·0565	·4390	·1130	·1888	1·2541	·2034	·1017	·002421
MO-40	" Harvest	Aug. 27	251·3	216·1180	35·1820	4·4882	·0251	·0754	·8092	·1834	·3317	2·0205	·2793	·1206	·004523
MO- 2	Stalks—Seedling	June 10	1·67	1·6032	·0668	·0174	·0001	·0005	·0021	·0006	·0004	·0069	·0006	·0018	·000008
MO- 5	" Early growth	July 13	1·85	1·6447	·2054	·0423	·0010	·0027	·0065	·0020	·0008	·0182	·0041	·0013	·000015
MO- 8	" Intermediate	July 22	18·5	17·1680	1·3320	·3003	·0026	·0120	·0263	·0102	·0072	·0683	·0111	·0107	·000148
MO-12	" Mid-vegetative	July 28	49·5	45·0450	4·4550	·9588	·0064	·0178	·0861	·0252	·0203	·2119	·0307	·0396	·000297
MO-17	" Late vegetative	Aug. 5	135·7	125·3868	10·3132	1·7383	·0095	·0041	·1954	·0366	·0556	·9160	·0706	·0543	·000679
MO-22	" Early bud	Aug. 8	206·6	189·6588	16·9412	2·6486	·0103	·0269	·3099	·0475	·0847	1·4152	·1178	·0806	·001446
MO-27	" Early bloom	Aug. 11	328·3	300·0662	28·2338	4·0479	·0131	·0624	·4826	·0952	·1280	2·1208	·2035	·1313	·001313
MO-32	" Late bloom	Aug. 19	403·1	378·1078	24·9922	3·2006	·0081	·0403	·4031	·0766	·0847	1·5519	·1814	·0806	·001612
MO-41	" Harvest	Aug. 27	585·6	515·3280	70·2720	9·6156	·0410	·1230	1·2883	·2518	·2928	4·6614	·2752	·3045	·007027
MO-36	" Late bloom (topped)	Aug. 19	388·7	354·8831	33·8169	3·8637	·0117	·0466	·5714	·1283	·1360	1·7608	·1127	·1866	·002721
MO-45	" Harvest (topped)	Aug. 27	382·2	340·1580	42·0420	5·3240	·0306	·0650	·8064	·1605	·1758	2·4270	·1299	·1949	·003822
	Total plant—Seedling	June 10	5·55	5·2659	·2841	·0700	·0003	·0014	·0085	·0034	·0018	·0169	·0027	·0048	·000035
	" Early growth	July 13	14·02	12·4692	1·5509	·3427	·0050	·0238	·0710	·0183	·0059	·0910	·0173	·0086	·000441
	" Intermediate	July 22	95·1	83·4640	11·6360	2·9687	·0225	·0837	·5282	·0793	·0621	·6156	·1133	·0688	·002384
	" Mid-vegetative	July 28	207·2	181·0756	26·1244	6·1065	·0460	·1187	1·0840	·2060	·1257	1·3528	·2756	·1514	·007501
	" Late vegetative	Aug. 5	479·5	431·4336	48·0664	9·5907	·0412	·1081	1·9719	·2674	·2801	4·0329	·4555	·1712	·012883
	" Early bud	Aug. 8	636·9	572·1420	64·7580	12·7568	·0479	·1588	2·6184	·3261	·3303	5·3170	·5906	·2038	·014754
	" Early bloom	Aug. 11	948·3	842·8668	105·4332	20·3995	·0792	·2929	4·3651	·5670	·4995	8·2319	·9348	·3217	·027408
	" Late bloom	Aug. 19	1254·3	1112·6070	141·6930	26·5621	·0835	·3991	5·7664	·7774	·6723	10·5235	1·3790	·3464	·021685
	" Harvest	Aug. 27	1704·5	1483·3600	221·1400	40·6996	·1352	·4889	8·7878	1·1256	1·1821	14·6601	1·4387	·8019	·045934
	" Late bloom (topped)	Aug. 19	1055·6	938·1397	117·4603	22·1086	·0631	·2232	5·6386	·8222	·5450	7·5164	·9082	·4291	·022504
	" Harvest (topped)	Aug. 27	1240·4	1088·8652	151·5348	28·2040	·0870	·2936	6·6640	·8115	·6609	9·5996	·9344	·5114	·033799

TABLE 9.—MINERAL-INTAKE EXPERIMENT—OTTAWA, 1937 (CIGAR TOBACCO)

Lab. No.	Description of Sample	Date of sampling	Dry Matter Basis (Moisture-free, Sand-free) Percentage									
			Ash	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	M
2-MO- 1	Five bottom leaves—Seedling stage	June 14	25·89	·155	·128	3·33	1·55	·89	7·95	·82	·50	·002
2-MO- 3	" Early growth	July 12	24·34	·244	·322	5·49	1·39	·55	8·50	·54	·30	·047
2-MO- 6	" Intermediate	July 22	25·25	·145	·176	4·84	1·19	·50	8·77	·53	·38	·028
2-MO- 9	" Mid-vegetative	July 30	27·44	·168	·239	6·49	1·15	·36	8·89	·46	·39	·039
2-MO-13	" Late vegetative	Aug. 2	27·91	·112	·141	6·22	1·51	·39	9·61	·69	·48	·063
2-MO-18	" Early bud	Aug. 6	28·64	·157	·199	6·92	1·75	·37	8·10	·64	·54	·065
2-MO-23	" Early bloom	Aug. 12	27·92	·136	·229	8·04	1·55	·36	8·16	·63	·32	·023
2-MO-28	" Late bloom	Aug. 19	28·35	·143	·151	7·74	1·72	·32	7·71	·66	·22	·101
2-MO-37	" Harvest	Aug. 26	28·47	·084	·098	6·86	1·22	·36	8·09	·82	·44	·040
2-MO-33	" Late bloom (topped)	Aug. 19	29·59	·131	·127	7·44	1·51	·44	9·95	·78	·48	·057
2-MO-42	" Harvest (topped)	Aug. 26	27·56	·223	·004	6·71	1·22	·94	8·15	·76	·30	·209
2-MO- 4	Five middle leaves—Early growth	July 12	20·99	·686	·717	2·45	1·28	1·13	7·29	·51	·51	·024
2-MO- 7	" Intermediate	July 27	20·32	·130	·547	2·62	·93	·85	7·78	·40	·42	·023
2-MO-10	" Mid-vegetative	July 30	22·29	·112	·028	3·81	·92	·66	8·88	·44	·45	·016
2-MO-14	" Late vegetative	Aug. 2	21·15	·062	·057	3·89	1·14	·66	8·57	·68	·41	·039
2-MO-19	" Early bud	Aug. 6	22·41	·097	·103	4·56	1·24	·51	8·81	·65	·50	·046
2-MO-24	" Early bloom	Aug. 12	20·94	·063	·023	4·99	·98	·55	7·04	·61	·31	·017
2-MO-29	" Late bloom	Aug. 19	22·60	·065	·065	5·08	1·11	·41	7·93	·66	·31	·053
2-MO-38	" Harvest	Aug. 26	23·37	·159	·000	4·99	·98	1·30	7·96	·81	·31	·157
2-MO-34	" Late bloom (topped)	Aug. 19	24·73	·067	·070	5·69	1·11	·57	9·86	·67	·38	·026
2-MO-43	" Harvest (topped)	Aug. 26	22·76	·090	·018	5·11	·86	1·31	8·40	·82	·43	·107
2-MO-11	Five top leaves—Mid-vegetative	July 30	18·30	·064	·050	2·14	·67	1·20	7·24	·66	·38	·010
2-MO-15	" Late vegetative	Aug. 2	16·53	·056	·055	2·48	·98	1·01	7·53	·67	·40	·024
2-MO-20	" Early bud	Aug. 6	18·40	·070	·112	5·02	1·07	·75	7·81	·67	·50	·020
2-MO-25	" Early bloom	Aug. 12	18·44	·062	·324	6·12	1·94	·96	6·97	·85	·31	·004
2-MO-30	" Late bloom	Aug. 19	19·52	·052	·066	3·80	1·07	·60	7·69	·70	·31	·043
2-MO-39	" Harvest	Aug. 26	18·67	·116	·000	3·92	·79	1·53	7·03	·92	·25	·137
2-MO-35	" Late bloom (topped)	Aug. 19	19·78	·056	·033	4·41	1·02	·75	7·97	·60	·34	·028
2-MO-44	" Harvest (topped)	Aug. 26	19·12	·067	·004	4·28	·78	1·59	7·13	·87	·49	·190
2-MO-16	Tops—Late vegetative	Aug. 2	12·83	·100	·158	2·50	1·85	1·92	7·12	·45	·48	·009
2-MO-21	" Early bud	Aug. 6	15·28	·099	·116	2·15	·89	1·42	6·00	·82	·50	·022
2-MO-26	" Early bloom	Aug. 12	14·14	·066	·034	2·68	1·05	1·51	6·02	·84	·42	·014
2-MO-31	" Late bloom	Aug. 19	13·41	·075	·086	2·32	1·01	1·09	6·11	·77	·39	·023
2-MO-40	" Harvest	Aug. 26	13·41	·170	·000	2·17	·61	2·40	5·78	·74	·37	·080
2-MO- 2	Stalks—Seedling stage	June 14	24·46	·071	·052	2·78	1·15	·71	14·78	·39	1·75	·002
2-MO- 5	" Early growth	July 12	18·31	·710	·628	1·99	·99	·70	6·32	·45	·53	·014
2-MO- 8	" Intermediate	July 22	19·17	·118	·159	2·14	·73	·60	10·18	·36	·54	·003
2-MO-12	" Mid-vegetative	July 30	20·48	·174	·062	1·56	·44	·61	9·72	·38	·77	·003
2iMO-17	" Late vegetative	Aug. 2	16·76	·049	·051	1·54	·69	·61	8·61	·42	·64	·006
2-MO-22	" Early bud	Aug. 6	15·00	·063	·058	1·49	·75	·56	7·47	·49	·68	·011
2-MO-27	" Early bloom	Aug. 12	14·78	·054	·075	1·85	·74	·54	6·86	·45	·45	·007
2-MO-32	" Late bloom	Aug. 19	12·84	·022	·009	1·45	·59	·44	6·32	·44	·31	·005
2-MO-41	" Harvest	Aug. 26	11·46	·022	·046	1·19	·33	1·09	6·00	·39	·34	·040
2-MO-36	" Late bloom (topped)	Aug. 19	11·62	·036	·014	1·57	1·25	·59	6·22	·30	·44	·004
2-MO-45	" Harvest (topped)	Aug. 26	11·28	·024	·032	1·37	·38	1·20	5·69	·54	·43	·036

TABLE 10.—MINERAL-INTAKE EXPERIMENT—OTTAWA, 1937 (CIGAR TOBACCO)

Lab. No.	Description of Sample	Date of sampling	Percentage of Ash							
			Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
2-MO- 1	Five bottom leaves—Seedling stage	June 14	·60	·49	12·86	5·99	3·44	30·71	3·17	5·02	·01
2-MO- 3	" Early growth	July 12	1·00	1·32	22·56	5·71	2·26	34·92	2·22	2·05	·19
2-MO- 6	" Intermediate	July 22	·57	·70	19·17	4·71	1·98	34·73	2·10	1·50	·11
2-MO- 9	" Mid-vegetative	July 30	·61	·87	23·65	4·19	1·31	32·40	1·68	1·42	·14
2-MO-13	" Late vegetative	Aug. 2	·40	·51	22·29	5·41	1·40	34·43	2·47	1·72	·23
2-MO-18	" Early bud	Aug. 6	·55	·69	24·16	6·11	1·29	28·28	2·23	1·89	·23
2-MO-23	" Early bloom	Aug. 12	·49	·82	28·80	5·55	1·29	29·23	2·26	1·15	·08
2-MO-28	" Late bloom	Aug. 19	·50	·53	27·30	6·07	1·13	27·20	2·33	·78	·36
2-MO-37	" Harvest	Aug. 26	·30	·34	24·10	4·29	1·26	28·42	2·38	1·55	·14
2-MO-33	" Late bloom (topped)	Aug. 19	·44	·43	25·14	5·10	1·49	33·63	2·64	1·62	·19
2-MO-42	" Harvest (topped)	Aug. 26	·81	·01	24·35	4·43	3·41	29·57	2·76	1·09	·76
2-MO- 4	Five middle leaves—Early growth	July 12	3·27	3·42	11·67	6·10	5·38	34·73	2·43	2·43	·11
2-MO- 7	" Intermediate	July 27	·64	2·69	12·89	4·58	4·18	38·29	1·96	2·07	·11
2-MO-10	" Mid-vegetative	July 30	·50	·13	17·09	4·13	2·96	39·84	1·97	2·02	·07
2-MO-14	" Late vegetative	Aug. 2	·29	·27	18·39	5·39	3·12	40·52	3·22	1·94	·18
2-MO-19	" Early bud	Aug. 6	·43	·46	20·35	5·53	2·28	36·50	2·90	2·23	·21
2-MO-24	" Early bloom	Aug. 12	·30	·11	23·83	4·68	2·63	33·62	2·91	1·48	·08
2-MO-29	" Late bloom	Aug. 19	·29	·29	22·48	4·91	1·81	35·09	2·92	1·37	·23
2-MO-38	" Harvest	Aug. 26	·68	·00	21·35	4·19	5·56	34·06	3·47	1·33	·67
2-MO-34	" Late bloom (topped)	Aug. 19	·27	·28	23·01	4·49	2·30	39·87	2·71	1·54	·11
2-MO-43	" Harvest (topped)	Aug. 26	·40	·08	22·45	3·78	5·76	36·91	3·60	1·89	·47
2-MO-11	Five top leaves—Mid-vegetative	July 30	·35	·31	11·69	3·66	6·56	37·56	3·61	2·08	·05
2-MO-15	" Late vegetative	Aug. 2	·34	·33	15·00	5·93	6·11	45·55	4·05	2·42	·15
2-MO-20	" Early bud	Aug. 6	·38	·61	27·28	5·82	4·08	42·45	3·64	2·72	·11
2-MO-25	" Early bloom	Aug. 12	·34	1·76	33·19	10·52	5·21	37·80	4·61	1·68	·02
2-MO-30	" Late bloom	Aug. 19	·27	·34	19·47	5·48	3·07	39·40	3·59	1·59	·22
2-MO-39	" Harvest	Aug. 26	·62	·00	21·00	4·23	8·19	37·65	4·93	1·34	·73
2-MO-35	" Late bloom (topped)	Aug. 19	·28	·17	22·30	5·16	3·79	40·29	3·03	1·72	·14
2-MO-44	" Harvest (topped)	Aug. 26	·35	·02	22·38	4·08	8·32	37·29	4·55	2·56	·99
2-MO-16	Tops—Late vegetative	Aug. 2	·78	1·23	19·49	14·42	14·96	55·49	3·51	3·74	·07
2-MO-21	" Early bud	Aug. 6	·65	·76	14·07	5·82	9·29	39·27	5·37	3·27	·14
2-MO-26	" Early bloom	Aug. 12	·47	·24	18·95	7·43	10·68	42·57	5·94	2·97	·10
2-MO-31	" Late bloom	Aug. 19	·56	·64	17·30	7·53	8·13	45·56	5·74	2·91	·17
2-MO-40	" Harvest	Aug. 26	1·77	·00	16·18	4·55	17·90	43·10	5·52	2·76	·60
2-MO- 2	Stalks—Seedling stage	June 14	·29	·21	11·37	4·70	2·90	60·43	1·59	7·15	·01
2-MO- 5	" Early growth	July 12	3·88	3·43	10·87	5·41	3·82	34·52	2·46	2·89	·08
2-MO- 8	" Intermediate	July 22	·62	·83	11·16	3·81	3·13	53·10	1·88	2·82	·02
2-MO-12	" Mid-vegetative	July 30	·85	·30	7·62	2·15	2·98	47·46	1·86	3·76	·01
2-MO-17	" Late vegetative	Aug. 2	·29	·30	9·19	4·12	3·64	51·37	2·51	3·82	·04
2-MO-22	" Early bud	Aug. 6	·42	·39	9·93	5·00	3·73	49·80	3·26	4·53	·07
2-MO-27	" Early bloom	Aug. 12	·37	·51	12·52	5·01	3·65	46·41	3·04	3·09	·05
2-MO-32	" Late bloom	Aug. 19	·17	·07	11·29	4·60	3·43	49·22	3·43	2·41	·04
2-MO-41	" Harvest	Aug. 26	·19	·40	10·38	2·88	9·51	52·36	3·40	2·97	·35
2-MO-36	" Late bloom (topped)	Aug. 19	·31	·12	13·51	10·76	5·08	53·53	2·58	3·79	·03
2-MO-45	" Harvest (topped)	Aug. 26	·21	·28	12·15	3·37	10·64	50·44	3·90	3·81	·32

TABLE 11.—MINERAL-INTAKE EXPERIMENT—OTTAWA, 1937 (CIGAR TOBACCO)

Lab. No.	Description of Sample	Date of Sampling	Green Matter Basis—Percentage											
			Moisture	Dry matter	Ash	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
2-MO- 1	Five bottom leaves–Seedling stage......	June 14	93·2	6·8	1·761	·011	·009	·226	·105	·061	·541	·056	·088	·0001
2-MO- 3	" Early growth......	July 12	90·4	9·6	2·337	·023	·031	·527	·133	·053	·816	·052	·048	·0045
2-MO- 6	" Intermediate.......	July 22	87·8	12·2	3·081	·018	·021	·590	·145	·061	1·070	·065	·046	·0034
2-MO- 9	" Mid-vegetative....	July 30	89·4	10·6	2·909	·018	·025	·688	·122	·038	·942	·049	·041	·0041
2-MO-13	" Late vegetative....	Aug. 2	90·2	9·8	2·735	·011	·014	·610	·148	·038	·942	·068	·047	·0062
2-MO-18	" Early bud.........	Aug. 6	88·2	11·8	3·380	·019	·023	·817	·207	·044	·956	·076	·064	·0077
2-MO-23	" Early bloom.......	Aug. 12	90·8	9·2	2·569	·013	·021	·740	·143	·033	·751	·058	·029	·0021
2-MO-28	" Late bloom........	Aug. 19	90·4	9·6	2·722	·014	·014	·743	·165	·031	·740	·063	·021	·0097
2-MO-37	" Harvest...........	Aug. 26	90·0	10·0	2·847	·008	·010	·686	·122	·036	·809	·082	·044	·0040
2-MO-33	" Late bloom (topped)	Aug. 19	91·8	8·2	2·426	·011	·010	·610	·124	·036	·816	·064	·039	·0047
2-MO-42	" Harvest (topped)...	Aug. 26	91·6	8·4	2·315	·019	·001	·564	·102	·079	·685	·064	·025	·0176
2-MO- 4	Five middle leaves-Early growth......	July 12	86·0	16·0	3·358	·110	·115	·392	·205	·181	1·166	·082	·082	·0038
2-MO- 7	" Intermediate.......	July 27	86·4	13·6	2·764	·018	·074	·356	·126	·116	1·058	·054	·057	·0031
2-MO-10	" Mid-vegetative....	July 30	89·8	10·2	2·274	·011	·003	·389	·094	·067	·906	·045	·046	·0016
2-MO-14	" Late vegetative....	Aug. 2	89·4	10·6	2·242	·007	·006	·412	·121	·070	·908	·072	·043	·0041
2-MO-19	" Early bud.........	Aug. 6	88·4	11·6	2·600	·011	·012	·529	·144	·059	·949	·075	·058	·0053
2-MO-24	" Early bloom.......	Aug. 12	90·8	9·2	1·926	·006	·002	·459	·090	·051	·648	·056	·029	·0016
2-MO-29	" Late bloom........	Aug. 19	89·4	10·6	2·396	·007	·007	·538	·118	·043	·841	·070	·033	·0056
2-MO-38	" Harvest...........	Aug. 26	89·0	11·0	2·571	·017	·000	·549	·108	·143	·876	·089	·034	·0173
2-MO-34	" Late bloom (topped)	Aug. 19	91·2	8·8	2·176	·006	·006	·501	·098	·050	·868	·059	·033	·0023
2-MO-43	" Harvest (topped)...	Aug. 26	89·6	10·4	2·367	·009	·002	·531	·089	·136	·874	·085	·045	·0111
2-MO-11	Five top leaves—Mid-vegetative.......	July 30	90·0	10·0	1·830	·006	·006	·214	·067	·120	·724	·066	·038	·0010
2-MO-15	" Late vegetative.......	Aug. 2	88·0	12·0	1·984	·007	·007	·298	·118	·121	·904	·080	·048	·0029
2-MO-20	" Early bud...........	Aug. 6	87·8	12·2	2·245	·009	·014	·612	·131	·092	·953	·082	·061	·0024
2-MO-25	" Early bloom..........	Aug. 12	90·0	10·0	1·844	·006	·032	·612	·194	·096	·697	·085	·031	·0004
2-MO-30	" Late bloom...........	Aug. 19	87·4	12·6	2·460	·007	·008	·479	·135	·076	·969	·088	·039	·0054
2-MO-39	" Harvest..............	Aug. 26	88·0	12·0	2·240	·014	·000	·470	·095	·184	·844	·110	·030	·0164
2-MO-35	" Late bloom (topped)..	Aug. 19	87·4	12·6	2·492	·007	·004	·556	·129	·095	1·004	·076	·043	·0035
2-MO-44	" Harvest (topped).....	Aug. 26	87·2	12·8	2·447	·009	·001	·548	·100	·204	·913	·111	·063	·0243
2-MO-16	Tops—Late vegetative................	Aug. 2	88·8	11·2	1·437	·011	·018	·280	·207	·215	·797	·050	·054	·0010
2-MO-21	" Early bud......................	Aug. 6	87·8	12·2	1·864	·012	·014	·262	·109	·173	·732	·100	·061	·0027
2-MO-26	" Early bloom....................	Aug. 12	89·8	10·2	1·442	·007	·003	·273	·107	·154	·614	·083	·043	·0014
2-MO-31	" Late bloom.....................	Aug. 19	86·8	13·2	1·770	·010	·011	·306	·133	·144	·807	·102	·051	·0030
2-MO-40	" Harvest........................	Aug. 26	86·0	14·0	1·877	·024	·000	·304	·085	·336	·809	·104	·052	·0112
2-MO- 2	Stalks—Seedling stage................	June 14	94·8	5·2	1·272	·004	·003	·145	·060	·037	·769	·020	·091	·0001
2-MO- 5	" Early growth.................	July 12	90·2	9·8	1·794	·070	·062	·195	·097	·069	·619	·044	·052	·0014
2-MO- 8	" Intermediate.................	July 22	91·2	8·8	1·687	·010	·014	·188	·064	·053	·896	·032	·048	·0003
2-MO-12	" Mid-vegetative...............	July 30	91·0	9·0	1·843	·016	·006	·140	·040	·055	·875	·034	·069	·0003
2-MO-17	" Late vegetative..............	Aug. 2	93·4	6·6	1·106	·003	·003	·102	·046	·040	·568	·028	·042	·0004
2-MO-22	" Early bud....................	Aug. 6	90·4	9·6	1·440	·006	·006	·143	·072	·054	·717	·047	·065	·0010
2-MO-27	" Early bloom..................	Aug. 12	92·0	8·0	1·182	·004	·006	·148	·059	·043	·549	·036	·036	·0006
2-MO-32	" Late bloom...................	Aug. 19	89·4	10·6	1·361	·002	·001	·154	·063	·047	·670	·047	·033	·0005
2-MO-41	" Harvest......................	Aug. 26	87·0	13·0	1·490	·003	·006	·155	·043	·142	·780	·051	·044	·0052
2-MO-36	" Late bloom (topped)..........	Aug. 19	90·0	10·0	1·162	·004	·001	·157	·125	·059	·622	·030	·044	·0004
2-MO-45	" Harvest (topped).............	Aug. 26	84·6	15·4	1·737	·004	·005	·211	·059	·185	·876	·068	·066	·0055

TABLE 12.—MINERAL-INTAKE EXPERIMENT—OTTAWA, 1937 (CIGAR TOBACCO)

Lab. No.	Description of Sample	Date of sampling	Absolute Weight per Plant in Grams: Total green weight	Moisture	Dry matter	Ash	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
2-MO- 1	Five bottom leaves—Seedling stage..	June 14	3·7	3·4	·3	·0652	·0004	·0003	·0084	·0039	·0023	·0200	·0021	·0033	·000004
2-MO- 3	" Early growth...	July 12	23·8	21·5	2·3	·5562	·0055	·0074	·1254	·0317	·0126	·1942	·0124	·0114	·001011
2-MO- 6	" Intermediate...	July 22	71·2	62·5	8·7	2·1937	·0128	·0150	·4201	·1032	·0434	·7618	·0463	·0328	·002421
2-MO- 9	" Mid-vegetative.	July 30	138·0	123·4	14·6	4·0144	·0248	·0345	·9494	·1684	·0524	1·3000	·0676	·0566	·005658
2-MO-13	" Late vegetative.	Aug. 2	194·5	175·4	19·1	5·3196	·0214	·0272	1·1865	·2879	·0739	1·8322	·1323	·0914	·012059
2-MO-18	" Early bud......	Aug. 6	268·6	236·9	31·7	9·0787	·0510	·0618	2·1945	·5560	·1182	2·5678	·2041	·1719	·020682
2-MO-23	" Early bloom....	Aug. 12	280·8	255·0	25·8	7·2138	·0365	·0590	2·0779	·4015	·0927	2·1088	·1629	·0814	·005897
2-MO-28	" Late bloom.....	Aug. 19	249·5	225·5	24·0	6·7914	·0349	·0349	1·8538	·4117	·0773	1·8463	·1572	·0524	·024202
2-MO-37	" Harvest.........	Aug. 26	365·4	328·9	36·5	10·4029	·0292	·0365	2·5066	·4458	·1315	2·9561	·2996	·1608	·014616
2-MO-33	" Late bloom (topped)......	Aug. 19	293·0	269·0	24·0	7·1082	·0322	·0293	1·7873	·3633	·1055	2·3909	·1875	·1143	·013771
2-MO-42	" Harvest (topped)......	Aug. 26	341·7	313·0	28·7	7·9104	·0649	·0034	1·9272	·3485	·2699	2·3406	·2187	·0854	·060139
2-MO- 4	Five middle leaves—Early growth...	July 12	6·4	5·5	1·0	·2149	·0070	·0074	·0251	·0131	·0116	·0746	·0052	·0052	·000243
2-MO- 7	" Intermediate...	July 27	42·0	36·3	5·7	1·1609	·0076	·0311	·1495	·0529	·0487	·4444	·0227	·0239	·001302
2-MO-10	" Mid-vegetative.	July 30	183·6	164·9	18·7	4·1751	·0202	·0055	·7142	·1726	·1230	1·6634	·0826	·0845	·002938
2-MO-14	" Late vegetative.	Aug. 2	234·8	209·9	24·9	5·2642	·0164	·0141	·9674	·2841	·1644	2·1320	·1691	·1010	·009627
2-MO-19	" Early bud......	Aug. 6	303·5	268·3	35·2	7·8910	·0334	·0364	1·6055	·4370	·1791	2·8802	·2276	·1760	·016207
2-MO-24	" Early bloom....	Aug. 12	289·2	262·6	26·6	5·5700	·0174	·0058	1·3274	·2603	·1475	1·8740	·1620	·0839	·004627
2-MO-29	" Late bloom.....	Aug. 19	276·4	247·1	29·3	6·6225	·0193	·0193	1·4870	·3262	·1189	2·3245	·1935	·0912	·015578
2-MO-38	" Harvest........	Aug. 26	352·0	313·3	38·7	9·0499	·0598	·0000	1·9325	·3802	·5034	3·0835	·3133	·1197	·060896
2-MO-34	" Late bloom (topped)........	Aug. 19	401·5	366·2	35·3	8·7366	·0241	·0241	2·0115	·3935	·2008	3·4850	·2369	·1325	·009235
2-MO-43	" Harvest (topped)......	Aug. 26	387·4	347·1	40·3	9·1698	·0349	·0077	2·0571	·3448	·5269	3·3859	·3293	·1743	·043001
2-MO-11	Five top leaves—Mid-vegetative.....	July 30	56·9	51·2	5·7	1·0413	·0034	·0034	·1218	·0381	·0683	·4120	·0376	·0216	·000569
2-MO-15	" Late vegetative.....	Aug. 2	83·4	73·4	10·0	1·6547	·0058	·0058	·2485	·0984	·1009	·7539	·0667	·0400	·002419
2-MO-20	" Early bud..........	Aug. 6	192·5	169·0	23·5	4·3216	·0173	·0270	1·1781	·2522	·1771	1·8345	·1579	·1174	·004620
2-MO-25	" Early bloom........	Aug. 12	208·6	187·7	20·9	3·8466	·0125	·0668	1·2766	·4047	·2003	1·4539	·1773	·0647	·000834
2-MO-30	" Late bloom.........	Aug. 19	298·8	261·2	37·6	7·3505	·0239	·0239	1·4313	·4034	·2271	2·8954	·2629	·1165	·016135
2-MO-39	" Harvest............	Aug. 26	303·9	267·4	36·5	6·8074	·0425	·0000	1·4283	·2887	·5592	2·5649	·3343	·0912	·049840
2-MO-35	" Late bloom (topped)	Aug. 19	577·6	504·8	72·8	14·3938	·0404	·0231	3·2115	·7451	·5487	5·7991	·4390	·2484	·020216
2-MO-44	" Harvest (topped)...	Aug. 26	427·6	372·9	54·7	10·4634	·0385	·0043	2·3432	·4276	·8723	3·9040	·4746	·2694	·103907

BLE 12.—MINERAL-INTAKE EXPERIMENT—OTTAWA, 1937 (CIGAR TOBACCO)—*Concluded*

Lab. No.	Description of Sample	Date of sampling	Absolute Weight per Plant in Grams												
			Total green weight	Moisture	Dry	Ash	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
2-MO-16	Tops—Late vegetative	Aug. 2	11·4	10·1	1·3	·1638	·0013	·0021	·0319	·0236	·0245	·0909	·0057	·0062	·000114
2-MO-21	" Early bud	Aug. 6	66·7	58·6	8·1	1·2433	·0080	·0013	·1748	·0727	·1154	·4882	·0667	·0407	·001801
2-MO-26	" Early bloom	Aug. 12	121·2	108·8	12·4	1·7477	·0085	·0036	·3309	·1297	·1866	·7442	·1042	·0521	·001697
2-MO-31	" Late bloom	Aug. 19	153·3	133·1	20·2	2·7134	·0153	·0168	·4691	·2039	·2208	1·2371	·1564	·0782	·004599
2-MO-40	" Harvest	Aug. 26	329·7	283·5	46·2	6·1885	·0791	·0000	1·0023	·2802	1·1078	2·1673	·3429	·1714	·036926
2-MO- 2	Stalks—Seedling stage	June 14	1·4	1·3	·1	·0178	·0001	·0001	·0020	·0008	·0005	·0108	·0003	·0013	·000001
2-MO- 5	" Early growth	July 12	4·5	4·1	·4	·0807	·0032	·0028	·0088	·0044	·0031	·0279	·0020	·0023	·000063
2-MO- 8	" Intermediate	July 22	24·0	21·9	2·1	·4049	·0024	·0034	·0451	·0154	·0127	·2150	·0077	·0115	·000072
2-MO-12	" Mid-vegetative	July 30	126·7	115·3	11·4	2·3351	·0203	·0076	·1774	·0507	·0697	1·1086	·0431	·0874	·000380
2-MO-17	" Late vegetative	Aug. 2	245·2	229·0	16·2	2·7119	·0074	·0074	·2501	·1128	·0981	1·3927	·0687	·1030	·000981
2-MO-22	" Early bud	Aug. 6	419·1	378·9	40·2	6·0350	·0251	·0251	·5993	·3018	·2263	3·0049	·1970	·2724	·004191
2-MO-27	" Early bloom	Aug. 12	466·1	428·8	37·3	5·5093	·0186	·0280	·6898	·2750	·2004	2·5589	·1678	·1678	·002797
2-MO-32	" Late bloom	Aug. 19	553·2	494·6	58·6	7·5291	·0111	·0055	·8519	·3485	·2600	3·7064	·2600	·1826	·002766
2-MO-41	" Harvest	Aug. 26	743·8	647·1	96·7	11·0826	·0223	·0446	1·1529	·3198	1·0562	5·8016	·3793	·3273	·038678
2-MO-36	" Late bloom (topped)	Aug. 19	696·1	626·5	69·6	8·0887	·0278	·0070	1·0927	·8701	·4107	4·3297	·2088	·3063	·002784
2-MO-45	" Harvest (topped)	Aug. 26	600·8	508·3	92·5	10·4359	·0240	·0300	1·2677	·3545	1·1115	5·2630	·4085	·3965	·033044
	Total plant—Seedling stage	June 14	5·1	4·7	·4	·0830	·0005	·0004	·0104	·0047	·0028	·0308	·0024	·0046	·000005
	" Early growth	July 12	34·7	31·1	3·7	·8518	·0157	·0176	·1593	·0492	·0273	·2967	·0196	·0189	·001377
	" Intermediate	July 22	137·2	120·7	16·5	3·7595	·0228	·0495	·6147	·1715	·1048	1·4212	·0767	·0682	·003795
	" Mid-vegetative	July 30	505·2	454·8	50·4	11·5659	·0687	·0510	1·9628	·4298	·3134	4·4840	·2309	·2501	·009545
	" Late vegetative	Aug. 2	769·3	697·8	71·5	15·1142	·0523	·0566	2·6844	·8068	·4618	6·2017	·4425	·3416	·025200
	" Early bud	Aug. 6	1250·4	1111·7	138·7	28·5696	·1348	·1596	5·7522	1·6197	·8161	10·7756	·8533	·7784	·047501
	" Early bloom	Aug. 12	1365·9	1242·9	123·0	23·8874	·0935	·1632	5·7026	1·4712	·8275	8·7398	·7742	·4499	·015852
	" Late bloom	Aug. 19	1531·2	1361·5	169·7	31·0069	·1015	·1004	6·0931	1·6937	·9041	12·0097	1·0300	·5209	·063280
	" Harvest	Aug. 26	2094·8	1840·2	254·6	43·5313	·2329	·0811	8·0226	1·7147	3·3581	17·0734	1·6694	·8704	·200956
	" Late bloom (topped)	Aug. 19	1968·2	1766·5	201·7	38·3273	·1255	·0835	8·1032	2·3720	1·2657	16·0047	1·0722	·8015	·046006
	" Harvest (topped)	Aug. 26	1757·5	1541·3	216·2	37·9795	·1623	·0454	7·5952	1·4754	2·7806	14·8935	1·4311	·9256	·240091

TABLE 13.—MINERAL-INTAKE EXPERIMENT—DELHI, 1936 (FLUE-CURED TOBACCO)

Lab. No.	Description of Sample	Date of sampling	Dry-matter Basis (Sand-free, Moisture-free) %								
			Fe_2O_3	Al_2O_3	$Fe_2O_3 + Al_2O_3$	CaO	MgO	P_2O_5	K_2O	S	Mn_3O_4
MD- 1	Bottom leaves—Seedling stage	June 3	·202	·019	·221	1·38	·29	·47	7·14	1·86	·032
MD- 3	" Early growth	July 2	·195	·070	·265	7·98	1·43	·30	5·37	·61	·024
MD- 7	" Intermediate	July 15	·097	·206	·303	8·15	1·68	·28	2·42	·64	·028
MD-12	" Mid-vegetative	July 30	·119	·256	·375	8·20	1·61	·27	2·94	·57	·052
MD- 4	First priming leaves—Early growth	July 2	·112	·000	·112	4·40	·90	·51	5·56	·48	·009
MD- 8	" Intermediate	July 15	·098	·139	·237	4·58	1·02	·35	2·48	·47	·021
MD-13	" Mid-vegetative	July 30	·089	·208	·297	5·08	·97	·27	2·15	·48	·026
MD-18	" Late vegetative	Aug. 7	·069	·174	·243	4·79	·91	·21	1·54	·45	·027
MD-24	" Early bud	Aug. 16	·085	·167	·252	5·98	1·08	·26	2·82	·43	·021
MD-30	" Late bloom	Aug. 24	·214	·154	·368	6·65	1·41	·33	2·76	·46	·038
MD- 5	Second priming leaves—Early growth	July 2	·146	·274	·420	2·06	1·03	·89	5·46	·36	·019
MD- 9	" Intermediate	July 15	·077	·244	·321	2·13	·62	·40	3·28	·45	·018
MD-14	" Mid-vegetative	July 30	·082	·124	·206	2·49	·63	·35	2·94	·39	·020
MD-19	" Late vegetative	Aug. 7	·071	·199	·270	2·60	·62	·25	1·97	·34	·020
MD-25	" Early bud	Aug. 16	·072	·097	·169	2·99	·59	·56	2·61	·28	·019
MD-31	" Late bloom	Aug. 24	·207	·127	·334	3·86	·63	·36	2·76	·40	·025
MD-10	Third priming leaves—Intermediate	July 15	·088	·206	·294	1·39	·75	·67	4·26	·47	·017
MD-15	" Mid-vegetative	July 30	·103	·136	·239	1·51	·70	·63	3·12	·46	·016
MD-20	" Late vegetative	Aug. 7	·080	·181	·261	1·82	·74	·61	2·77	·15	·021
MD-26	" Early bud	Aug. 16	·075	·109	·184	1·75	·56	·36	2·96	·28	·015
MD-32	" Late bloom	Aug. 24	·174	·078	·252	3·05	·57	·47	3·08	·45	·028
MD-16	Fourth priming leaves—Mid-vegetative	July 30	·119	·327	·446	3·35	·95	1·23	4·67	·60	·028
MD-21	" Late vegetative	Aug. 7	·080	·133	·213	1·54	·58	·68	2·62	·27	·017
MD-27	" Early bud	Aug. 16	·068	·164	·232	1·55	·64	·59	3·65	·35	·014
MD-33	" Late bloom	Aug. 24	·193	·063	·256	3·24	·72	·68	4·01	·58	·025
MD-22	Fifth priming leaves—Late vegative	Aug. 7	·088	·601	·689	3·25	1·63	1·10	4·76	·51	·033
MD-28	" Early bud	Aug. 16	·071	·208	·279	1·70	·94	1·35	4·61	·47	·016
MD-34	" Late bloom	Aug. 24	·208	·029	·237	3·43	·87	1·03	4·24	·61	·044
MD-35	Top leaves—Late bloom	Aug. 24	·188	·132	·320	3·01	1·01	1·67	5·56	·64	·029
MD-36	Tops—late bloom	Aug. 24	·193	·223	·416	2·36	·99	1·84	5·05	·68	·019
MD- 2	Stalks—Seedling stage	June 3	·536	·000	·536	7·47	1·63	·69	9·22	·66	·080
MD- 6	" Early growth	July 2	·085	·148	·233	1·85	·77	·56	6·16	·47	·011
MD-11	" Intermediate	July 15	·079	·142	·221	1·78	·72	·32	3·59	·40	·013
MD-17	" Mid-vegetative	July 30	·062	·084	·146	1·63	·54	·25	3·01	·39	·011
MD-23	" Late vegetative	Aug. 7	·027	·125	·152	1·46	·59	·23	2·07	·31	·008
MD-29	" Early bud	Aug. 16	·035	·123	·158	1·13	·59	·23	2·69	·26	·009
MD-37	" Late bloom	Aug. 24	·053	·053	·106	1·19	·40	·28	2·65	·35	·007

TABLE 14.—MINERAL-INTAKE EXPERIMENT—DELHI, 1936 (FLUE-CURED TOBACCO)

Lab. No.	Description of Sample	Date of sampling	Green-Matter Basis %									
			Moisture	Dry matter	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Mn_3O_4
MD- 1	Bottom leaves—Seedling stage	June 3	91·10	8·90	·018	·002	·123	·026	·042	·635	·166	·0028
MD- 3	" Early growth	July 2	87·06	12·94	·025	·009	1·033	·185	·039	·695	·079	·0031
MD- 7	" Intermediate	July 15	82·07	17·93	·017	·037	1·461	·301	·050	·434	·115	·0050
MD-12	" Mid-vegetative	July 30	84·72	15·28	·018	·039	1·253	·246	·041	·449	·087	·0079
MD- 4	First priming leaves—Early growth	July 2	88·70	11·30	·013	·000	·497	·102	·058	·628	·054	·0010
MD- 8	" Intermediate	July 15	78·42	21·58	·021	·030	·988	·220	·076	·535	·101	·0045
MD-13	" Mid-vegetative	July 30	79·92	20·08	·018	·042	1·020	·195	·054	·432	·096	·0052
MD-18	" Late vegetative	Aug. 7	80·40	19·60	·014	·034	·939	·178	·041	·302	·088	·0053
MD-24	" Early bud	Aug. 16	79·90	20·10	·017	·034	1·202	·217	·052	·567	·086	·0042
MD-30	" Late bloom	Aug. 24	82·10	17·90	·038	·028	1·190	·252	·059	·494	·082	·0068
MD- 5	Second priming leaves—Early growth	July 2	87·32	12·68	·019	·035	·261	·131	·113	·692	·046	·0024
MD- 9	" Intermediate	July 15	78·10	21·90	·017	·053	·466	·136	·088	·718	·099	·0039
MD-14	" Mid-vegetative	July 30	75·83	24·17	·020	·030	·602	·152	·085	·711	·094	·0048
MD-19	" Late vegetative	Aug. 7	75·70	24·30	·017	·048	·632	·151	·061	·479	·083	·0049
MD-25	" Early bud	Aug. 16	73·30	26·70	·019	·026	·798	·158	·150	·697	·075	·005
MD-31	" Late bloom	Aug. 26	81·60	18·40	·038	·023	·710	·116	·066	·508	·074	·0046
MD-10	Third priming leaves—Intermediate	July 15	81·30	18·70	·016	·039	·260	·140	·125	·797	·088	·0032
MD-15	" Mid-vegetative	July 30	79·24	20·76	·021	·028	·313	·145	·131	·648	·095	·0033
MD-20	" Late vegetative	Aug. 7	75·10	24·90	·020	·045	·453	·184	·152	·690	·037	·0052
MD-26	" Early bud	Aug. 16	73·00	27·00	·020	·029	·473	·151	·097	·799	·076	·0041
MD-32	" Late bloom	Aug. 24	78·70	21·30	·037	·017	·650	·121	·100	·656	·096	·0060
MD-16	Fourth priming leaves—Mid-vegetative	July 30	82·88	11·72	·014	·038	·393	·111	·144	·547	·070	·0033
MD-21	" Late vegetative	Aug. 7	83·00	17·00	·014	·023	·262	·099	·116	·445	·046	·0029
MD-27	" Early bud	Aug. 16	78·40	21·60	·015	·035	·335	·138	·127	·788	·076	·0030
MD-33	" Late bloom	Aug. 24	81·50	18·50	·036	·012	·599	·133	·126	·742	·107	·0046
MD-22	Fifth priming leaves—Late vegetative	Aug. 7	82·80	17·20	·015	·103	·559	·280	·189	·819	·088	·0057
MD-28	" Early bud	Aug. 16	83·90	16·10	·011	·033	·274	·151	·217	·742	·076	·0026
MD-34	" Late bloom	Aug. 24	82·60	17·40	·036	·005	·597	·151	·179	·738	·106	·0077
MD-35	Top leaves—Late bloom	Aug. 24	82·80	17·20	·032	·023	·518	·174	·287	·956	·110	·0050
MD-36	Tops—Late bloom	Aug. 24	84·90	15·10	·029	·034	·356	·149	·278	·763	·103	·0029
MD- 2	Stalks—Seedling stage	June 3	93·00	7·00	·038	·000	·523	·114	·048	·645	·046	·0056
MD- 6	" Early growth	July 2	90·08	9·92	·008	·015	·184	·076	·056	·656	·047	·0011
MD-11	" Intermediate	July 15	85·73	14·27	·011	·020	·254	·103	·046	·512	·057	·0019
MD-17	" Mid-vegetative	July 30	85·64	14·36	·009	·012	·234	·078	·036	·432	·056	·0016
MD-23	" Late vegetative	Aug. 7	83·90	16·10	·004	·020	·235	·095	·039	·333	·050	·0013
MD-29	" Early bud	Aug. 16	83·00	17·00	·006	·021	·192	·100	·039	·457	·044	·0015
MD-37	" Late bloom	Aug. 24	82·30	17·70	·009	·009	·211	·071	·050	·469	·062	·0012

TABLE 15.—MINERAL-INTAKE EXPERIMENT—DELHI, 1936 (FLUE-CURED TOBACCO)

Lab. No.	Description of Sample	Date of sampling	Absolute Weight per Plant—Grams										
			Total green weight	Moisture	Dry matter	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Mn_3O_4
MD- 1	Bottom leaves—Seedling stage	June 3	2·8	2·5508	·2492	·0005	·0001	·0034	·0007	·0012	·0178	·0046	·000078
MD- 3	" Early growth	July 2	16·2	14·1037	2·0963	·0041	·0015	·1673	·0300	·0063	·1126	·0128	·000502
MD- 7	" Intermediate	July 15	14·8	12·1464	2·6536	·0025	·0055	·2162	·0445	·0074	·0642	·0170	·000740
MD-12	" Mid-vegetative	July 30	14·3	12·1150	2·1850	·0026	·0056	·1792	·0352	·0059	·0642	·0124	·001130
MD- 4	First priming leaves—Early growth	July 2	40·9	36·2783	4·6217	·0053	·0000	·2033	·0417	·0237	·2569	·0221	·000409
MD- 8	" Intermediate	July 15	21·2	16·6250	4·5750	·0045	·0064	·2095	·0466	·0161	·1134	·0214	·000954
MD-13	" Mid-vegetative	July 30	40·2	32·1278	8·0722	·0072	·0169	·4100	·0784	·0217	·1737	·0386	·002090
MD-18	" Late vegetative	Aug. 7	54·0	43·4160	10·5840	·0076	·0184	·5071	·0961	·0221	·1631	·0475	·002862
MD-24	" Early bud	Aug. 16	65·0	51·9350	13·0650	·0111	·0221	·7813	·1411	·0338	·3686	·0559	·002730
MD-30	" Late bloom	Aug. 24	48·7	39·9827	8·7173	·0185	·0136	·5795	·1227	·0287	·2406	·0399	·003312
MD- 5	Second priming leaves—Early growth	July 2	5·8	5·0646	·7354	·0011	·0020	·0151	·0076	·0066	·0401	·0027	·000139
MD- 9	" Intermediate	July 15	32·5	25·3825	7·1175	·0055	·0172	·1515	·0442	·0286	·2334	·0322	·001268
MD-14	" Mid-vegetative	July 30	51·5	39·0525	12·4476	·0103	·0155	·3100	·0783	·0438	·3662	·0484	·002472
MD-19	" Late vegetative	Aug. 7	72·0	54·5040	17·4960	·0122	·0346	·4550	·1087	·0439	·3449	·0598	·003528
MD-25	" Early bud	Aug. 16	81·0	59·3730	21·6270	·0154	·0211	·6464	·1280	·1215	·5646	·0608	·004131
MD-31	" Late bloom	Aug. 24	68·0	55·4880	12·5120	·0258	·0156	·4828	·0789	·0449	·3454	·0503	·003128
MD-10	Third priming leaves—Intermediate	July 15	10·4	8·4552	1·9448	·0017	·0041	·0270	·0146	·0130	·0829	·0092	·000332
MD-15	" Mid-vegetative	July 30	23·6	18·7006	4·8994	·0050	·0066	·0739	·0342	·0309	·1529	·0224	·000779
MD-20	" Late vegetative	Aug. 7	45·0	33·7950	11·2050	·0090	·0203	·2039	·0828	·0684	·3105	·0167	·002340
MD-26	" Early bud	Aug. 16	65·0	47·4500	17·5500	·0130	·0189	·3075	·0982	·0631	·5194	·0494	·002665
MD-32	" Late bloom	Aug. 24	86·3	67·9181	18·3819	·0319	·0147	·5610	·1044	·0863	·5661	·0828	·005178
MD-16	Fourth priming leaves—Mid-vegetative	July 30	3·6	2·9837	·4219	·0005	·0014	·0141	·0040	·0052	·0197	·0025	·000119
MD-21	" Late vegetative	Aug. 7	21·0	17·4300	3·5700	·0029	·0048	·0550	·0208	·0244	·0935	·0097	·000609
MD-27	" Early bud	Aug. 16	26·0	20·3840	5·6160	·0039	·0091	·0871	·0359	·0330	·2049	·0198	·000780
MD-33	" Late bloom	Aug. 24	47·0	38·3050	8·6950	·0169	·0056	·2815	·0625	·0592	·3487	·0503	·002162

MD-22	Fifth priming leaves—Late vegetative	Aug. 7	7·0	5·7960	1·2040	·0011	·0142	·0391	·0587	·0132	·0573	·0062	·006559
MD-28	" Early bud	Aug. 16	16·0	13·4240	2·5760	·0018	·0053	·0438	·0242	·0347	·1187	·0122	·000416
MD-34	" Late bloom	Aug. 24	37·7	31·1402	6·5598	·0136	·0019	·2251	·0569	·0675	·2782	·0400	·002903
MD-35	Top leaves—Late bloom	Aug. 24	24·7	20·4516	4·2484	·0079	·0057	·1279	·0430	·0709	·2361	·0272	·001235
MD-36	Tops—Late bloom	Aug. 24	19·3	16·3857	2·9143	·0056	·0066	·0687	·0288	·0537	·1473	·0199	·000560
MD- 2	Stalks—Seedling stage	June 3	1·7	1·5810	·1190	·0006	·0000	·0089	·0019	·0008	·0110	·0008	·000095
MD- 6	" Early growth	July 2	10·2	9·1882	1·0118	·0008	·0015	·0188	·0078	·0057	·0669	·0048	·000112
MD-11	" Intermediate	July 15	26·1	22·3755	3·7245	·0029	·0052	·0663	·0269	·0120	·1336	·0149	·000496
MD-17	" Mid-vegetative	July 30	54·6	46·7594	7·8406	·0049	·0066	·1278	·0426	·0197	·2359	·0306	·000874
MD-23	" Late vegetative	Aug. 7	106·0	88·9340	17·0660	·0042	·0212	·2491	·1007	·0413	·3530	·0530	·001378
MD-29	" Early bud	Aug. 16	141·0	117·0300	23·9700	·0085	·0296	·2707	·1410	·0550	·6444	·0620	·002115
MD-37	" Late bloom	Aug. 24	220·0	181·0600	38·9400	·0198	·0198	·4642	·1562	·1100	1·0318	·1364	·002640
	Total plant—Seedling stage	June 3	4·5	4·1318	·3682	·0011	·0001	·0123	·0026	·0020	·0288	·0054	·000173
	" Early growth	July 2	73·1	64·6348	8·4652	·0113	·0050	·4045	·0871	·0423	·4765	·0424	·001586
	" Intermediate	July 15	105·0	84·9846	20·0154	·0171	·0384	·6705	·1768	·0771	·6275	·0947	·003790
	" Mid-vegetative	July 30	187·8	151·7390	35·8687	·0305	·0526	1·1150	·2727	·1272	1·0126	·1549	·007464
	" Late vegetative	Aug. 7	305·0	243·8750	61·1250	·0370	·1135	1·5092	·4678	·2133	1·3223	·1929	·017276
	" Early bud	Aug. 16	394·0	309·5960	84·4040	·0537	·1061	2·1368	·5684	·3411	2·4206	·2601	·012837
	" Late bloom	Aug. 24	551·7	450·7313	100·9687	·1400	·0835	2·7907	·6534	·5212	3·1942	·4468	·021118

TABLE 16.—MINERAL-INTAKE EXPERIMENT—DELHI, 1937 (FLUE-CURED TOBACCO)

Lab. No.	Description of Sample	Date of Sampling	Dry-Matter Basis (Sand-free, Moisture-free)—Percentage									
			Ash	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
2 MD- 1	Bottom leaves—Seedling stage	June 3	21·74	·105	·119	5·17	·71	·92	6·89	2·53	·47	·028
2 MD- 3	" Early growth	June 29	24·88	·209	·287	6·16	1·36	·58	6·80	·81	2·24	·071
2-MD- 7	" Intermediate	July 9	29·71	·206	·412	8·29	1·52	·51	6·09	1·14	1·88	·144
2-MD-12	" Mid-vegetative	July 13	26·29	·166	·320	8·50	1·54	·64	5·57	1·10	1·90	·077
2 MD-17	" Late vegetative	July 17	27·58	·345	·047	8·91	1·54	·38	5·88	1·10	1·78	·196
2-MD-23	" Early bud	July 22	28·08	·480	·000	9·95	1·57	·35	4·78	1·29	1·91	·226
2-MD-30	" Early bloom	July 28	25·42	·306	·246	10·06	1·56	·30	3·14	1·11	1·44	·108
2-MD- 4	First priming leaves—Early growth	June 29	20·80	·282	·680	4·15	1·22	·87	6·60	·59	1·56	·063
2-MD- 8	" Intermediate	July 9	21·82	·190	·215	5·21	·76	·71	6·15	·96	1·51	·080
2-MD-13	" Mid-vegetative	July 13	21·06	·124	·256	5·91	1·13	·63	5·42	1·10	1·12	·066
2-MD-18	" Late vegetative	July 17	21·56	·320	·000	5·08	·92	·58	6·06	·93	1·13	1·00
2-MD-24	" Early bud	July 22	18·89	·267	·000	6·00	·76	·49	4·36	·95	·80	·112
2-MD-31	" Early bloom	July 28	17·66	·101	·075	5·98	·83	·45	3·59	·82	·61	·079
2-MD-38	" Late bloom	July 30	19·12	·089	·140	6·44	1·06	1·07	4·06	1·16	·72	·129
2-MD-45	" Harvest	Aug. 5	20·34	·127	·153	7·46	1·05	·98	3·44	·85	·99	·284
2-MD- 5	Second priming leaves—Early growth	June 29	14·54	·447	1·019	1·94	1·17	1·13	6·67	·52	1·09	·055
2-MD- 9	" Intermediate	July 9	15·92	·211	·256	2·83	·79	·98	6·56	·79	·92	·060
2-MD-14	" Mid-vegetative	July 13	13·90	·086	·250	2·88	·75	·90	5·38	·80	·78	·033
2-MD-19	" Late vegetative	July 17	14·44	·142	·000	2·96	·59	·79	5·52	·73	·87	·051
2-MD-25	" Early bud	July 22	12·45	·061	·000	3·31	·46	·43	3·79	·60	·50	·048
2-MD-32	" Early bloom	July 28	11·35	·045	·028	3·08	·38	·45	3·26	·61	·38	·054
2-MD-39	" Late bloom	July 30	14·67	·050	·023	4·01	·61	1·14	3·66	·73	·47	·277
2-MD-46	" Harvest	Aug. 5	14·12	·049	·047	6·46	·58	1·15	3·32	·69	·50	·273
2-MD-10	Third priming leaves—Intermediate	July 9	10·74	·183	·180	2·01	·57	1·58	5·54	·77	·77	·048
2-MD-15	" Mid-vegetative	July 13	12·54	·144	·000	2·04	·48	1·39	5·11	·80	·77	·017
2-MD-20	" Late vegetative	July 17	11·68	·155	·000	1·93	·58	1·03	4·94	·83	·57	·040
2-MD-26	" Early bud	July 22	10·80	·039	·028	2·25	·34	·54	4·50	·67	·44	·038
2-MD-33	" Early bloom	July 28	9·32	·034	·066	2·11	·31	·54	3·00	·51	·34	·030
2-MD-40	" Late bloom	July 30	10·30	·036	·009	2·83	·45	1·16	3·19	·69	·31	·155
2-MD-47	" Harvest	Aug. 5	10·66	·047	·033	3·78	·51	1·00	3·10	·60	·53	·128

2-MD-21	Fourth priming leaves—Late vegetative	July 17	13·09	·095	·113	3·76	·80	1·69	6·47	1·23	1·27	·009
2-MD-27	" Early bud	July 22	9·29	·065	·000	1·62	·39	·88	3·74	·60	·56	·029
2-MD-34	" Early bloom	July 28	8·99	·037	·038	1·80	·37	·69	3·21	·59	·60	·019
2-MD-41	" Late bloom	July 30	10·37	·022	·018	2·58	·49	1·50	3·80	·72	·65	·076
2-MD-48	" Harvest	Aug. 5	10·58	·033	·009	2·61	·59	1·22	3·74	·56	·75	·090
2-MD-35	Fifth priming leaves—Early bloom	July 28	10·52	·087	·047	2·25	·57	1·33	4·51	·75	·79	·045
2-MD-42	" Late bloom	July 30	10·47	·021	·047	2·08	·58	2·33	4·14	·70	·67	·060
2-MD-49	" Harvest	Aug. 5	10·21	·081	·046	2·04	·49	2·15	4·22	·62	·93	·062
2-MD-28	Tops—Early bud	July 22	11·96	·174	·000	4·37	·25	1·53	7·54	·95	1·27	·049
2-MD-36	" Early bloom	July 28	13·21	·136	·186	2·92	·50	1·73	5·88	·86	·99	·044
2-MD-43	" Late bloom	July 30	11·82	·122	·809	1·88	·95	3·91	4·75	·72	·68	·077
2-MD-50	" Harvest	Aug. 5	12·45	·141	·042	1·53	·62	3·45	4·95	·60	·29	·053
2-MD- 2	Stalks—Seedlings	June 3	22·31	·071	·000	2·75	·48	·85	10·57	1·23	1·27	·021
2-MD- 6	" Early Growth	June 29	16·18	·130	·146	2·00	·54	·66	6·76	·47	1·84	·023
2-MD-11	" Intermediate	July 9	14·21	·079	·082	1·52	·41	·70	6·25	·52	1·51	·022
2-MD-16	" Mid-vegetative	July 13	14·25	·150	·000	1·51	·42	·68	5·71	·46	1·60	·016
2-MD-22	" Late vegetative	July 17	12·63	·088	·000	1·59	·43	·59	5·99	·48	1·23	·014
2-MD-29	" Early bud	July 22	10·44	·030	·009	1·44	·23	·50	4·71	·50	·89	·010
2-MD-37	" Early bloom	July 28	9·41	·024	·000	1·37	·50	·55	4·97	·37	·84	·014
2-MD-44	" Late bloom	July 30	7·89	·021	·004	1·52	·40	1·04	3·09	·44	·63	·041
2-MD-51	" Harvest	Aug. 5	5·49	·121	·000	1·19	·20	1·08	3·31	·46	·58	·028

TABLE 17.—MINERAL-INTAKE EXPERIMENT—DELHI, 1937 (FLUE-CURED TOBACCO)

Lab. No.	Description of Sample	Date of Sampling	Percentage of Ash								
			Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
2-MD- 1	Bottom leaves—Seedling stage	June 3	·48	·55	23·78	3·27	4·23	31·69	11·64	2·16	·13
2-MD- 3	" Early growth	June 29	·84	1·15	24·76	5·47	2·33	27·33	3·26	9·00	·29
2-MD- 7	" Intermediate	July 9	·69	1·39	27·90	5·12	1·72	20·50	3·84	6·33	·48
2-MD-12	" Mid-vegetative	July 13	·63	1·22	32·33	5·86	2·43	21·19	4·18	7·23	·29
2-MD-17	" Late vegetative	July 17	1·25	·17	32·31	5·58	1·38	21·32	3·99	6·45	·71
2-MD-23	" Early bud	July 22	1·71	·00	35·43	5·59	1·25	17·02	4·59	6·80	·80
2-MD-30	" Early bloom	July 28	1·20	·97	39·58	6·14	1·18	12·35	4·37	5·66	·42
2-MD- 4	First priming leaves—Early growth	June 29	1·36	3·27	19·95	5·87	4·18	31·73	2·84	7·50	·30
2-MD- 8	" Intermediate	July 9	·87	·99	23·88	3·48	3·25	28·19	4·40	6·92	·37
2-MD-13	" Mid-vegetative	July 13	·59	1·22	28·06	5·37	2·99	25·74	5·22	5·32	·31
2-MD-18	" Late vegetative	July 17	1·48	·00	23·56	4·27	2·69	28·11	4·31	5·24	·46
2-MD-24	" Early bud	July 22	1·41	·00	31·76	4·02	2·59	23·08	5·03	4·24	·59
2-MD-31	" Early bloom	July 28	·57	·42	33·86	4·70	2·55	20·33	4·64	3·45	·45
2-MD-38	" Late bloom	July 30	·47	·73	33·68	5·54	5·60	21·23	6·07	3·77	·67
2-MD-45	" Harvest	Aug. 5	·62	·75	36·68	5·16	4·82	16·91	4·18	4·87	1·40
2-MD- 5	Second priming leaves—Early growth	June 29	3·07	7·01	13·34	8·05	7·77	45·87	3·58	7·50	·38
2-MD- 9	" Intermediate	July 9	1·33	1·61	17·78	4·96	6·16	41·21	4·96	5·78	·38
2-MD-14	" Mid-vegetative	July 13	·62	1·80	20·72	5·40	6·47	38·71	5·76	5·61	·24
2-MD-19	" Late vegetative	July 17	·98	·00	20·50	4·09	5·47	38·23	5·06	6·02	·35
2-MD-25	" Early bud	July 22	·49	·00	26·59	3·69	3·45	30·44	4·82	4·02	·39
2-MD-32	" Early bloom	July 28	·40	·25	27·14	3·35	3·96	28·72	5·37	3·35	·48
2-MD-39	" Late bloom	July 30	·34	·16	27·33	4·16	7·77	29·95	4·98	3·20	1·89
2-MD-46	" Harvest	Aug. 5	·35	·33	45·75	4·11	8·14	23·51	4·89	3·54	1·93
2-MD-10	Third priming leaves—Intermediate	July 9	1·70	1·68	18·72	5·31	14·71	51·57	7·17	7·17	·45
2-MD-15	" Mid-vegetative	July 13	1·15	·00	16·27	3·83	11·08	40·75	6·38	6·14	·14
2-MD-20	" Late vegetative	July 17	1·33	·00	16·52	4·97	8·82	42·29	7·11	4·88	·34
2-MD-26	" Early bud	July 22	·36	·26	20·83	3·15	5·00	41·67	6·20	4·07	·35
2-MD-33	" Early bloom	July 28	·36	·71	22·64	3·33	5·79	32·19	5·47	3·65	·32
2-MD-40	" Late bloom	July 30	·35	·09	27·48	4·37	11·26	30·97	6·70	3·01	1·50
2-MD-47	" Harvest	Aug. 5	·44	·31	35·46	4·78	9·38	29·08	5·63	4·97	1·20

2-MD-21	Fourth priming leaves—Late vegetative......	July 17	·73	·86	28·72	6·11	12·91	49·43	9·40	9·70	·07
2-MD-27	" Early bud...........	July 22	·70	·00	17·44	4·20	9·47	40·26	6·46	6·03	·31
2-MD-34	" Early bloom.........	July 28	·41	·42	20·02	4·12	7·68	35·71	6·56	6·67	·21
2-MD-41	" Late bloom..........	July 30	·21	·17	24·88	4·73	14·46	36·64	6·94	6·27	·73
2-MD-48	" Harvest.............	Aug. 5	·31	·09	24·67	5·58	11·53	35·35	5·29	7·09	·85
2-MD-35	Fifth priming leaves—Early bloom..........	July 28	·83	·45	21·39	5·42	12·64	42·87	7·13	7·51	·43
2-MD-42	" Late bloom...........	July 30	·20	·45	19·87	5·54	22·25	39·54	6·69	6·40	·57
2-MD-49	" Harvest..............	Aug. 5	·79	·45	19·98	4·80	21·06	41·33	6·07	9·11	·61
2-MD-28	Tops—Early bud...........................	July 22	1·45	·00	36·54	2·09	12·79	63·04	7·94	10·62	·41
2-MD-36	" Early bloom........................	July 28	1·03	1·41	22·10	3·79	13·10	44·51	6·51	7·49	·33
2-MD-43	" Late bloom.........................	July 30	1·03	·75	15·91	8·04	33·08	40·19	6·09	5·75	·65
2-MD-50	" Harvest............................	Aug. 5	1·13	·34	12·29	3·98	27·71	39·76	4·82	2·33	·43
2-MD- 2	Stalks—Seedlings.........................	June 3	·32	·00	12·33	2·15	3·81	47·38	5·51	5·69	·09
2-MD- 6	" Early growth.......................	June 29	·80	·90	12·36	3·34	4·08	41·78	2·90	11·37	·14
2-MD-11	" Intermediate.......................	July 9	·56	·58	10·70	2·89	4·93	43·98	3·66	10·63	·15
2-MD-16	" Mid-vegetative.....................	July 13	1·05	·00	10·60	2·95	4·77	40·07	3·23	11·23	·11
2-MD-22	" Late vegetative....................	July 17	·70	·00	12·59	3·40	4·67	47·43	3·80	9·74	·11
2-MD-29	" Early bud..........................	July 22	·29	·09	13·79	2·20	4·79	45·11	4·79	8·52	·10
2-MD-37	" Early bloom........................	July 28	·26	·00	14·56	5·31	5·84	52·82	3·93	8·93	·15
2-MD-44	" Late bloom.........................	July 30	·27	·05	19·26	5·07	13·18	39·16	5·58	7·98	·52
2-MD-51	" Harvest............................	Aug. 5	2·20	·00	21·68	3·64	19·67	60·29	8·38	10·56	·51

TABLE 18.—MINERAL-INTAKE EXPERIMENT—DELHI, 1937 (FLUE-CURED TOBACCO)

Lab. No.	Description of Sample	Date of sampling	Green-matter Basis—Percentage											
			Moisture	Dry matter	Ash	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
2-MD- 1	Bottom leaves—Seedling stage	June 3	92·4	7·6	1·652	·008	·009	·393	·054	·070	·524	·192	·036	·0021
2-MD- 3	" Early growth	June 29	88·4	11·6	2·886	·024	·033	·715	·158	·067	·789	·094	·260	·0082
2-MD- 7	" Intermediate	July 9	88·8	11·2	3·328	·023	·046	·928	·170	·057	·682	·128	·211	·0161
2-MD-12	" Mid-vegetative	July 13	90·1	9·9	2·603	·016	·032	·842	·152	·063	·552	·109	·188	·0076
2-MD-17	" Late vegetative	July 17	89·3	10·7	2·951	·037	·005	·953	·165	·041	·629	·118	·190	·0210
2-MD-23	" Early bud	July 22	87·4	12·6	3·538	·060	·000	1·254	·198	·044	·602	·163	·241	·0285
2-MD-30	" Early bloom	July 28	87·0	13·0	3·305	·040	·032	1·308	·203	·039	·408	·144	·187	·0140
2-MD- 4	First priming leaves—Early growth	June 29	87·8	12·2	2·538	·034	·083	·506	·149	·106	·805	·072	·190	·0077
2-MD- 8	" Intermediate	July 9	88·5	11·5	2·509	·022	·025	·599	·087	·082	·707	·110	·174	·0092
2-MD-13	" Mid-vegetative	July 13	89·5	10·5	2·211	·013	·027	·621	·119	·066	·569	·116	·118	·0069
2-MD-18	" Late vegetative	July 17	88·9	11·1	2·393	·036	·000	·564	·102	·064	·673	·103	·125	·0111
2-MD-24	" Early bud	July 22	85·6	14·4	2·720	·038	·000	·864	·109	·071	·628	·137	·115	·0161
2-MD-31	" Early bloom	July 28	85·5	14·5	2·561	·015	·011	·867	·120	·065	·521	·119	·088	·0115
2-MD-38	" Late bloom	July 30	85·1	14·9	2·849	·013	·021	·960	·158	·159	·605	·173	·107	·0192
2-MD-45	" Harvest	Aug. 5	84·8	15·2	3·092	·019	·023	1·134	·160	·149	·523	·129	·150	·0431
2-MD- 5	Second priming leaves—Early growth	June 29	85·7	14·3	2·079	·064	·146	·277	·167	·162	·954	·074	·156	·0079
2-MD- 9	" Intermediate	July 9	86·8	13·2	2·101	·028	·034	·374	·104	·129	·866	·104	·121	·0079
2-MD-14	" Mid-vegetative	July 13	89·9	10·1	1·404	·009	·025	·291	·076	·091	·543	·081	·079	·0033
2-MD-19	" Late vegetative	July 17	89·3	10·7	1·545	·015	·000	·317	·063	·085	·591	·078	·093	·0055
2-MD-25	" Early bud	July 22	84·1	15·9	1·980	·010	·000	·526	·073	·068	·603	·095	·080	·0076
2-MD-32	" Early bloom	July 28	81·1	18·9	2·145	·009	·005	·582	·072	·085	·616	·115	·072	·0102
2-MD-39	" Late bloom	July 30	81·6	18·4	2·699	·009	·004	·738	·112	·210	·673	·134	·086	·0510
2-MD-46	" Harvest	Aug. 5	82·8	17·2	2·429	·008	·008	1·111	·100	·198	·571	·119	·086	·0470
2-MD-10	Third priming leaves—Intermediate	July 9	86·6	13·4	1·439	·025	·024	·269	·076	·212	·742	·103	·103	·0064
2-MD-15	" Mid-vegetative	July 13	89·3	10·7	1·342	·015	·000	·218	·051	·149	·547	·086	·082	·0018
2-MD-20	" Late vegetative	July 17	87·3	12·7	1·483	·020	·000	·245	·074	·131	·627	·105	·072	·0051
2-MD-26	" Early bud	July 22	83·8	16·2	1·750	·006	·005	·365	·055	·087	·729	·109	·071	·0062
2-MD-33	" Early bloom	July 28	80·2	19·8	1·845	·007	·013	·418	·061	·107	·594	·101	·067	·0059
2-MD-40	" Late bloom	July 30	81·1	18·9	1·947	·007	·002	·535	·085	·219	·603	·130	·059	·0293
2-MD-47	" Harvest	Aug. 5	79·8	20·2	2·153	·009	·007	·764	·103	·202	·626	·121	·107	·0259

2-MD-21	Fourth priming leaves—Late vegetative......	July 17	89·0	11·0	1·440	·010	·012	·414	·088	·186	·712	·135	·140	·0010
2-MD-27	" Early bud...........	July 22	83·9	16·1	1·496	·010	·000	·261	·063	·142	·602	·097	·090	·0047
2-MD-34	" Early bloom..........	July 28	82·6	17·4	1·564	·006	·007	·313	·064	·120	·559	·103	·104	·0033
2-MD-41	" Late bloom..........	July 30	81·1	18·9	1·960	·004	·003	·488	·093	·284	·718	·136	·123	·0144
2-MD-48	" Harvest.............	Aug. 5	79·3	20·7	2·190	·007	·002	·540	·122	·253	·774	·116	·155	·0186
2-MD-35	Fifth priming leaves—Early bloom...........	July 28	84·0	16·0	1·683	·014	·008	·360	·091	·213	·722	·120	·126	·0072
2-MD-42	" Late bloom............	July 30	82·9	17·1	1·790	·004	·008	·356	·099	·398	·708	·120	·115	·0103
2-MD-49	" Harvest...............	Aug. 5	79·5	20·5	2·093	·017	·009	·418	·100	·441	·865	·127	·191	·0127
2-MD-28	Tops—Early bud..............................	July 22	87·2	12·8	1·531	·022	·000	·559	·032	·196	·965	·122	·163	·0063
2-MD-36	" Early bloom..........................	July 28	87·4	12·5	1·651	·017	·023	·365	·063	·216	·735	·108	·124	·0055
2-MD-43	" Late bloom...........................	July 30	84·6	15·4	1·820	·019	·014	·290	·146	·602	·732	·111	·105	·0119
2-MD-50	" Harvest..............................	Aug. 5	85·0	15·0	1·868	·021	·006	·230	·093	·518	·743	·090	·044	·0080
2-MD- 2	Stalks—Seedlings............................	June 3	94·2	5·8	1·294	·004	·000	·160	·028	·049	·613	·071	·074	·0012
2-MD- 6	" Early growth........................	June 29	89·7	10·3	1·667	·013	·015	·206	·056	·068	·696	·048	·190	·0024
2-MD-11	" Intermediate........................	July 9	90·0	10·0	1·421	·008	·008	·152	·041	·070	·625	·052	·151	·0022
2-MD-16	" Mid-vegetative......................	July 13	92·7	7·3	1·040	·011	·000	·110	·031	·050	·417	·034	·117	·0012
2-MD-22	" Late vegetative.....................	July 17	90·8	9·2	1·162	·008	·000	·146	·040	·054	·551	·044	·113	·0013
2-MD-29	" Early bud...........................	July 22	90·0	10·0	1·044	·003	·001	·144	·023	·050	·471	·050	·089	·0010
2-MD-37	" Early bloom.........................	July 28	88·2	11·8	1·110	·003	·000	·162	·059	·065	·586	·044	·099	·0017
2-MD-44	" Late bloom..........................	July 30	86·9	13·1	1·034	·003	·001	·199	·052	·136	·405	·058	·083	·0054
2-MD-51	" Harvest.............................	Aug. 5	85·4	14·6	·802	·018	·000	·174	·029	·158	·483	·067	·085	·0041

TABLE 19.—MINERAL-INTAKE EXPERIMENT—DELHI, 1937 (Flue-cured Tobacco)

Lab. No.	Description of Sample	Date of Sampling	Absolute Weight per Plant in Grams												
			Total green weight	Moisture	Dry matter	Ash	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
2-MD- 1	Bottom leaves—Seedling stage......	June 3	2·2	2·0	·1672	·0363	·0002	·0002	·0086	·0012	·0015	·0015	·0042	·0008	·000046
2-MD- 3	" Early growth.......	June 29	11·4	10·1	1·3224	·3290	·0027	·0038	·0815	·0180	·0076	·0899	·0107	·0296	·000935
2-MD- 7	" Intermediate........	July 9	17·2	15·3	1·9264	·5724	·0040	·0079	·1596	·0292	·0098	·1173	·0220	·0363	·002769
2-MD-12	" Mid-vegetative.....	July 13	22·1	19·9	2·1879	·5753	·0035	·0071	·1861	·0336	·0139	·1220	·0241	·0415	·001680
2-MD-17	" Late vegetative.....	July 17	33·7	30·1	3·6059	·9945	·0125	·0017	·3212	·0556	·0138	·2120	·0398	·0640	·007077
2-MD-23	" Early bud..........	July 22	25·0	21·9	3·1500	·8845	·0150	·0000	·3135	·0495	·0110	·1505	·0408	·0603	·007125
2-MD-30	" Early bloom........	July 28	12·3	10·7	1·5990	·4065	·0049	·0039	·1609	·0250	·0048	·0502	·0177	·0230	·003943
2-MD- 4	First priming leaves—Early growth.	June 29	18·9	16·6	2·3058	·4797	·0064	·0157	·0956	·0282	·0200	·1521	·0136	·0359	·001455
2-MD- 8	" Intermediate..	July 9	69·5	61·5	7·9925	1·7438	·0153	·0174	·4163	·0605	·0570	·4914	·0765	·1209	·006394
2-MD-13	" Mid-vegetative	July 13	109·2	97·7	11·4660	2·4144	·0142	·0295	·6781	·1299	·0721	·6213	·1267	·1289	·007535
2-MD-18	" Late vegetative..	July 17	129·1	114·8	14·3301	3·0894	·0465	·0000	·7281	·1317	·0826	·8688	·1330	·1614	·014330
2-MD-24	" Early bud.....	July 22	127·5	109·1	18·3600	3·4680	·0485	·0000	1·1016	·1390	·0905	·8007	·1747	·1466	·020528
2-MD-31	" Early bloom..	July 28	118·0	100·9	17·1100	3·0220	·0177	·0130	1·0231	·1416	·0767	·6148	·1404	·1038	·013570
2-MD-38	" Late bloom...	July 30	146·0	124·2	21·7540	4·1595	·0190	·0307	1·4016	·2307	·2321	·8833	·2526	·1562	·028032
2-MD-45	" Harvest.......	Aug. 5	115·0	97·5	17·4800	3·5558	·0219	·0265	1·3041	·1840	·1714	·6015	·1484	·1725	·049565
2-MD- 5	Second priming leaves–Early growth	June 29	2·1	1·8	·3003	·0437	·0013	·0031	·0058	·0035	·0034	·0200	·0016	·0033	·000166
2-MD- 9	" Intermediate.	July 9	48·8	42·4	6·4416	1·0253	·0137	·0166	·1825	·0508	·0630	·4226	·0508	·0590	·003855
2-MD-14	" Mid-vegetative.	July 13	108·9	97·9	10·9989	1·5290	·0098	·0272	·3169	·0827	·0991	·5913	·0882	·0860	·003594
2-MD-19	" Late vegetative.	July 17	152·6	136·3	16·3282	2·3577	·0229	·0000	·4837	·0961	·1297	·9019	·1190	·1419	·008393
2-MD-25	" Early bud....	July 22	173·7	146·1	27·6183	3·4393	·0174	·0000	·9137	·1268	·1181	1·0474	·1650	·1390	·013201
2-MD-32	" Early bloom.	July 28	188·0	152·5	35·5320	4·0326	·0169	·0094	1·0942	·1354	·1598	1·1581	·2162	·1354	·019176
2-MD-39	" Late bloom..	July 30	217·0	177·1	39·9280	5·8568	·0195	·0087	1·6015	·2430	·4557	1·4604	·2908	·1866	·110670
2-MD-46	" Harvest......	Aug. 5	198·0	163·9	34·0560	4·8094	·0158	·0158	2·1998	·1980	·3920	1·1306	·2356	·1703	·093060
2-MD-10	Third priming leaves—Intermediate.	July 9	3·9	3·4	·5226	·0561	·0010	·0009	·0105	·0030	·0083	·0289	·0040	·0040	·000250
2-MD-15	" Mid-vegetative.	July 13	26·8	23·9	2·8676	·3597	·0040	·0000	·0584	·0137	·0399	·1466	·0230	·0220	·000482
2-MD-20	" Late vegetative.	July 17	56·7	49·5	7·2009	·8409	·0113	·0000	·1389	·0420	·0743	·3555	·0595	·0408	·002892

2-MD-26	" Early bud....	July 22	135·3	113·4	21·9186	2·3678	·0081	·0068	·4938	·0744	·1177	·9863	·1475	·0961	·008389
2-MD-33	" Early bloom.	July 28	133·0	106·7	26·3340	2·4539	·0093	·0173	·5559	·0811	·1423	·7900	·1343	·0871	·007847
2-MD-40	" Late bloom..	July 30	181·0	146·8	34·2090	3·5241	·0127	·0036	·9684	·1539	·3964	1·0914	·2353	·1068	·053033
2-MD-47	" Harvest......	Aug. 5	166·0	132·5	33·5320	3·5740	·0149	·0116	1·2682	·1710	·3353	1·0392	·2009	·1776	·042974
2-MD-21	Fourth priming leaves—Late vegetative.	July 17	4·9	4·4	·5390	·0706	·0005	·0006	·0203	·0043	·0091	·0349	·0066	·0069	·000049
2-MD-27	" Early bud...	July 22	44·1	37·0	7·1001	·6597	·0044	·0000	·1151	·0278	·0626	·2655	·0428	·0397	·002093
2-MD-34	" Early bloom	July 28	65·7	54·3	11·4318	1·0275	·0039	·0046	·2056	·0420	·0788	·3673	·0677	·0683	·002168
2-MD-41	" Late bloom.	July 30	107·5	87·2	20·3175	2·1070	·0043	·0032	·5246	·1000	·3053	·7719	·1462	·1322	·015480
2-MD-48	" Harvest.....	Aug. 5	92·7	73·5	19·1889	2·0301	·0065	·0019	·5006	·1131	·2345	·7175	·1075	·1437	·017242
2-MD-35	Fifth priming leaves—Early bloom..	July 28	12·5	10·5	2·0000	·2104	·0018	·0010	·0450	·0114	·0266	·0903	·0150	·0158	·000900
2-MD-42	" Late bloom...	July 30	36·7	30·4	6·2757	·6569	·0015	·0029	·1307	·0363	·1461	·2598	·0440	·0422	·003780
2-MD-49	" Harvest......	Aug. 5	38·5	30·6	7·8925	·8058	·0065	·0035	·1609	·0385	·1698	·3330	·0489	·0735	·004890
2-MD-28	Tops—Early bud....................	July 22	7·3	6·4	·9344	·1118	·0016	·0000	·0408	·0023	·0143	·0704	·0089	·0119	·000460
2-MD-36	" Early bloom.................	July 28	9·7	8·5	1·2125	·1601	·0016	·0022	·0354	·0061	·0210	·0713	·0105	·0120	·000534
2-MD-43	" Late bloom..................	July 30	25·0	21·2	3·8500	·4550	·0048	·0035	·0725	·0365	·1505	·1830	·0278	·0263	·002975
2-MD-50	" Harvest.....................	Aug. 5	36·0	30·6	5·4000	·6725	·0076	·0022	·0828	·0335	·1865	·2675	·0324	·0158	·002880
2-MD- 2	Stalks—Seedling...................	June 3	1·1	1·0	·0638	·0142	·0001	·0000	·0018	·0003	·0005	·0067	·0008	·0008	·000013
2-MD- 6	" Early growth..............	June 29	4·0	3·6	·4120	·0667	·0005	·0006	·0082	·0022	·0027	·0278	·0019	·0076	·000096
2-MD-11	" Intermediate...............	July 9	38·1	34·3	3·8100	·5414	·0030	·0030	·0579	·0156	·0267	·2381	·0198	·0575	·000838
2-MD-16	" Mid-vegetative............	July 13	93·3	86·5	6·8109	·9703	·0103	·0000	·1026	·0289	·0467	·3891	·0317	·1092	·001120
2-MD-22	" Late vegetative............	July 17	160·6	145·8	14·7752	1·8662	·0128	·0000	·2345	·0642	·0867	·8849	·0707	·1815	·002088
2-MD-29	" Early bud...................	July 22	280·7	252·6	28·0700	2·9305	·0084	·0028	·4042	·0646	·1404	1·3221	·1404	·2498	·002807
2-MD-37	" Early bloom...............	July 28	308·0	271·7	36·3440	3·4188	·0092	·0000	·4990	·1817	·2002	1·8049	·1355	·3049	·005236
2-MD-44	" Late bloom.................	July 30	443·0	385·0	58·0330	4·5806	·0133	·0044	·8816	·2304	·6025	1·7942	·2569	·3677	·023922
2-MD-51	" Harvest.....................	Aug. 5	393·0	335·6	57·3780	3·1519	·0707	·0000	·6838	·1140	·6209	1·8982	·2633	·3341	·015113
	Total plant—Seedling stage..........	June 3	3·3	3·0	·2310	·0505	·0003	·0002	·0104	·0015	·0020	·0182	·0050	·0016	·000059
	" Early growth..........	June 29	36·4	32·1	4·3405	·9191	·0109	·0232	·1911	·0519	·0337	·2898	·0278	·0764	·002652
	" Intermediate...........	July 9	177·5	156·9	20·6931	3·9390	·0370	·0458	·8268	·1591	·1648	1·2839	·1731	·2777	·014106
	" Mid-vegetative........	July 13	360·3	325·9	34·3313	5·8469	·0418	·0638	1·3421	·2888	·2717	1·8944	·2937	·3876	·014411
	" Late vegetative........	July 17	537·6	480·9	56·7793	9·2193	·1065	·0023	1·9267	·3939	·3962	3·2580	·4286	·5965	·024829
	" Early bud.............	July 22	793·6	686·5	107·1514	13·8616	·1034	·0096	3·3827	·4844	·5546	4·6429	·7201	·7434	·054583
	" Early bloom...........	July 28	847·2	715·8	131·5633	14·7318	·0653	·0514	3·6191	·6243	·7102	4·9469	·7373	·7523	·053374
	" Laté bloom............	July 30	1156·2	971·9	184·3672	21·3399	·0751	·0570	5·5809	1·0308	2·2886	6·4440	1·2536	1·0180	·237892
	" Harvest...............	Aug. 5	1039·2	864·2	174·9274	18·5995	·1439	·0615	6·2002	·8521	2·1104	5·9875	1·0370	1·0875	·226744

TABLE 20.—MINERAL-INTAKE EXPERIMENT—DELHI, 1940 (FLUE-CURED TOBACCO)

Lab. No.	Description of Sample	Date of sampling	Dry Matter Basis (Sand-free, Moisture-free)									
			Ash	Fe_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4	N.
3-MD- 1	Bottom leaves—Seedling stage	June 5	25·72	·059	3·85	1·14	1·08	6·62	1·71	2·52	·061	4·97
3-MD- 3	" Early growth	July 3	18·23	·071	5·10	·95	·56	4·36	·71	·61	·017	2·25
3-MD- 7	" Intermediate	July 16	24·55	·114	7·29	1·41	·54	4·64	1·12	·26	·028	1·91
3-MD-12	" Mid-vegetative	July 19	20·71	·085	7·01	1·05	·55	3·58	1·12	·15	·040	....
3-MD-17	" Late vegetative	July 22	21·74	·106	8·21	1·29	·70	6·52	1·03	·31	·031	....
3-MD-23	" Early bud	July 24	23·39	·094	8·60	1·43	·59	1·69	1·12	·47	·021	....
3-MD-30	" Early bloom	July 27	22·30	·103	7·88	1·62	·60	2·06	1·27	·50	·034	....
3-MD- 4	First priming leaves—Early growth	July 3	16·79	·100	2·47	·81	·84	4·11	·79	·29	·015	2·68
3-MD- 8	" Intermediate	July 16	19·35	·056	4·66	·80	·39	4·02	·80	·19	·018	2·00
3-MD-13	" Mid-vegetative	July 19	16·33	·074	5·02	·84	·62	1·32	1·03	·16	·022	2·15
3-MD-18	" Late vegetative	July 22	15·75	·053	4·92	·82	·72	2·22	·87	·10	·013	1·80
3-MD-24	" Early bud	July 24	15·30	·060	4·89	·78	·58	3·07	·67	·07	·013	1·59
3-MD-31	" Early bloom	July 27	15·89	·067	4·76	·94	·63	1·74	·88	·03	·018	1·57
3-MD-37	" Late bloom	Aug. 7	15·74	·049	5·17	·93	·57	2·07	·79	·03	·029	1·44
3-MD-42	" Harvesting I—Unprimed	Aug. 15	15·93	·042	6·04	·97	·48	2·43	·76	·07	·024	1·29
3-MD-51	" " II "	Aug. 26	15·79	·046	5·73	·80	·65	2·38	·48	·16	·029	1·15
3-MD-59	" " III "	Sept. 10	18·08	·045	6·32	1·01	·83	2·27	·59	·07	·031	1·20
3-MD- 5	Second priming leaves—Early growth	July 3	14·98	·140	1·83	1·01	1·25	4·45	·86	·42	·021	....
3-MD- 9	" Intermediate	July 16	17·10	·029	2·42	·57	·82	3·86	·66	·22	·006	3·19
3-MD-14	" Mid-vegetative	July 19	12·26	·046	2·62	·38	·71	2·52	·75	·19	·017	2·84
3-MD-19	" Late vegetative	July 22	12·90	·034	3·03	·61	·78	3·43	·54	·15	·012	2·82
3-MD-25	" Early bud	July 24	13·85	·029	3·09	·83	·65	2·58	·56	·12	·001	2·36
3-MD-32	" Early bloom	July 27	12·43	·046	3·07	·76	·58	2·42	·65	·03	·015	2·33
3-MD-38	" Late bloom	Aug. 7	11·23	·032	3·30	·90	·49	2·09	·51	·07	·011	1·83
3-MD-43	" Harvesting I—Unprimed	Aug. 15	10·91	·024	3·81	·64	·44	2·27	·51	·07	·016	1·46
3-MD-52	" " II "	Aug. 26	12·88	·020	3·74	·72	·49	·90	·94	·22	·021	1·36
3-MD-60	" " III "	Sept. 10	14·72	·034	4·69	·69	·60	·53	·46	·10	·020	1·33
3-MD-47	" " I—Primed	Aug. 15	11·91	·022	4·16	·58	·54	1·97	·57	·10	·019	1·64
3-MD-10	Third priming leaves—Intermediate	July 16	12·74	·040	2·92	1·12	1·57	4·05	·97	·30	·008	....
3-MD-15	" Mid-vegetative	July 19	11·69	·052	2·06	·53	1·17	1·15	·80	·30	·004	....
3-MD-20	" Late vegetative	July 22	10·08	·035	1·98	·66	1·21	2·84	·71	·12	·011	....
3-MD-26	" Early bud	July 24	11·44	·028	2·13	·66	·83	1·84	·63	·19	·007	3·50
3-MD-33	" Early bloom	July 27	12·48	·054	2·23	·75	·76	1·94	·52	·12	·014	3·26
3-MD-39	" Late bloom	Aug. 7	9·98	·026	2·70	·64	·50	1·66	·48	·18	·014	2·28
3-MD-44	" Harvesting I—Unprimed	Aug. 15	10·52	·020	3·50	·69	·43	2·26	·49	·22	·016	1·81
3-MD-53	" " II "	Aug. 26	12·01	·018	3·52	·57	·47	2·27	·46	·38	·021	1·61
3-MD-61	" " III "	Sept. 10	11·47	·022	4·57	·78	·56	·46	·54	·22	·021	1·39

3-MD-48	" " I—Primed	Aug. 15	10·40	·018	3·17	·49	·51	2·08	·53	·22	·023	1·94
3-MD-56	" " II "	Aug. 26	14·37	·027	4·41	·75	·55	2·08	·60	·12	·017	1·54
3-MD-21	Fourth priming leaves—Late vegetative	July 22	12·77	·064	3·85	·61	2·08	4·77	1·51	·30	·016	....
3-MD-27	" Early bud	July 24	10·57	·044	1·91	1·13	1·28	1·81	·80	·15	·007	....
3-MD-34	" Early bloom	July 27	10·12	·058	1·90	·72	1·08	2·68	·60	·07	·016	....
3-MD-40	" Late bloom	Aug. 7	10·67	·022	2·52	·69	·68	3·03	·54	·31	·012	3·14
3-MD-45	" Harvesting I—Unprimed	Aug. 15	10·69	·016	3·10	·70	·49	2·47	·55	·42	·015	2·32
3-MD-54	" " II "	Aug. 26	15·76	·018	3·48	·64	·37	2·40	·50	·78	·024	1·96
3-MD-62	" " III "	Sept. 10	12·36	·020	5·18	·77	·51	·39	·54	·41	·020	1·67
3-MD-49	" " I—Primed	Aug. 15	13·96	·025	3·08	·64	·53	2·01	·56	·49	·026	2·51
3-MD-57	" " II "	Aug. 26	15·91	·019	4·27	·79	·46	1·29	·48	·34	·018	2·05
3-MD-64	" " III "	Sept. 10	13·72	·021	5·51	·87	·45	·67	·47	·62	·026	1·97
3-MD-28	Tops—Early bud	July 24	11·81	·067	5·87	2·95	2·02	3·24	1·39	·08	·009	....
3-MD-35	" —Early bloom	July 27	11·85	·032	1·07	·51	·76	1·02	·64	·03	·008	....
3-MD- 2	Stalks—Seedling stage	June 5	23·02	·030	2·31	·70	·79	10·57	·68	3·57	·022	....
3-MD- 6	" Early growth	July 3	15·91	·110	1·73	·74	·73	4·02	·66	·68	·012	1·74
3-MD-11	" Intermediate	July 16	16·71	·041	2·12	·64	·70	6·28	·64	·49	·002	1·55
3-MD-16	" Mid-vegetative	July 19	12·28	·036	1·50	·50	·62	3·56	·69	·54	·006	1·53
3-MD-22	" Late vegetative	July 22	11·12	·029	1·76	·45	·61	2·88	·65	·34	·008	1·28
3-MD-29	" Early bud	July 24	9·46	·024	1·62	·63	·53	2·33	·55	·31	·002	1·18
3-MD-36	" Early bloom	July 27	9·17	·023	1·57	·47	·49	1·92	·37	·23	·006	·98
3-MD-41	" Late bloom	Aug. 7	7·21	·015	1·60	·47	·39	2·18	·52	·23	·005	·95
3-MD-46	" Harvesting I—Unprimed	Aug. 15	7·18	·011	1·47	·46	·45	1·07	·49	·39	·002	·99
3-MD-55	" " II "	Aug. 26	11·65	·015	2·01	·41	·41	2·07	·54	·55	·009	·92
3-MD-63	" " III "	Sept. 10	7·18	·015	2·32	·45	·45	·66	·46	·28	·009	·77
3-MD-50	" " I—Primed	Aug. 15	10·44	·018	1·93	·39	·30	·54	·43	·38	·007	·83
3-MD-58	" " II "	Aug. 26	11·60	·013	1·96	·50	·38	·58	·66	·41	·005	·89
3-MD-65	" " "	Sept. 10	7·61	·037	2·34	·50	·80	1·57	·45	·62	·003	·87

TABLE 21.—MINERAL-INTAKE EXPERIMENT—DELHI, 1940 (FLUE-CURED TOBACCO)

Lab. No.	Description of Sample	Date of sampling	Percentage of Ash							
			Fe_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
3-MD- 1	Bottom leaves—Seedling stage	June 5	·23	14·97	4·43	4·20	25·74	6·65	9·80	·24
3-MD- 3	" Early growth	July 3	·39	27·98	5·21	3·07	23·92	3·89	3·35	·09
3-MD- 7	" Intermediate	July 16	·46	29·69	5·74	2·20	18·90	4·56	1·06	·11
3-MD-12	" Mid-vegetative	July 10	·41	33·85	5·07	2·66	17·29	5·41	·72	·19
3-MD-17	" Late vegetative	July 22	·49	37·76	5·93	3·22	29·99	4·74	1·43	·14
3-MD-23	" Early bud	July 24	·40	36·77	6·11	2·52	7·23	4·79	2·01	·09
3-MD-30	" Early bloom	July 27	·46	33·82	7·26	2·69	9·24	5·70	2·24	·15
3-MD- 4	First priming leaves—Early growth	July 3	·60	14·71	4·82	5·00	24·48	4·71	1·73	·09
3-MD- 8	" Intermediate	July 16	·29	24·08	4·13	2·02	20·78	4·13	·98	·09
3-MD-13	" Mid-vegetative	July 19	·45	30·74	5·14	3·80	8·08	6·31	·98	·13
3-MD-18	" Late vegetative	July 22	·34	31·24	5·21	4·57	14·10	5·52	·63	·08
3-MD-24	" Early bud	July 24	·39	31·96	5·10	3·79	20·07	4·38	·46	·08
3-MD-31	" Early bloom	July 27	·42	29·96	5·92	3·96	10·95	5·54	·19	·11
3-MD-37	" Late bloom	Aug. 7	·31	32·85	5·91	3·62	13·15	5·02	·19	·18
3-MD-42	" Harvesting I—Unprimed	Aug. 15	·26	37·92	6·09	3·01	15·25	4·77	·44	·15
3-MD-51	" " II "	Aug. 26	·29	36·29	5·07	4·12	15·07	3·04	1·01	·18
3-MD-59	" " III "	Sept. 10	·25	34·96	5·59	4·59	12·56	3·26	·39	·17
3-MD- 5	Second priming leaves—Early growth	July 3	·93	12·22	6·74	8·34	29·71	5·79	2·80	·14
3-MD- 9	" Intermediate	July 16	·17	14·15	3·33	4·80	22·57	3·86	1·29	·04
3-MD-14	" Mid-vegetative	July 19	·38	21·37	3·10	5·79	20·55	6·12	1·55	·14
3-MD-19	" Late vegetative	July 22	·26	23·48	4·73	6·05	26·59	4·19	1·16	·09
3-MD-25	" Early bud	July 24	·21	22·31	5·99	4·69	18·63	4·04	·87	·01
3-MD-32	" Early bloom	July 27	·37	24·70	6·11	4·67	27·51	5·23	·24	·12
3-MD-38	" Late bloom	Aug. 7	·28	29·39	8·01	4·36	18·61	4·54	·62	·10
3-MD-43	" Harvesting I—Unprimed	Aug. 15	·22	34·92	5·87	4·03	20·81	4·67	·64	·15
3-MD-52	" " II "	Aug. 26	·16	29·04	5·59	3·80	6·99	7·30	1·71	·16
3-MD-60	" " III "	Sept. 10	·23	31·86	4·69	4·08	3·60	3·13	·68	·14
3-MD-47	" " I—Primed	Aug. 15	·18	34·93	4·87	4·53	16·54	4·79	·84	·16

3-MD-10	Third priming leaves—Intermediate	July 16	·31	22·92	8·79	12·32	31·79	7·61	2·35	·06
3-MD-15	" Mid-vegetative	July 19	·44	17·62	4·53	10·01	9·84	6·84	2·57	·03
3-MD-20	" Late vegetative	July 22	·35	19·64	6·55	12·00	28·17	7·04	1·19	·11
3-MD-26	" Early bud	July 24	·24	18·62	5·77	7·26	16·08	5·51	1·66	·06
3-MD-33	" Early bloom	July 27	·43	17·87	6·01	6·09	15·54	4·17	·96	·11
3-MD-39	" Late bloom	Aug. 7	·26	27·05	6·41	5·01	16·53	4·81	1·80	·14
3-MD-44	" Harvesting I—Unprimed	Aug. 15	·19	33·27	6·56	4·09	21·48	4·66	2·09	·15
3-MD-53	" " II "	Aug. 26	·14	29·31	4·75	3·91	18·90	3·83	3·16	·17
3-MD-61	" " III "	Sept. 10	·19	39·84	6·80	4·88	4·01	4·71	1·92	·18
3-MD-48	" " I—Primed	Aug. 15	·17	30·48	4·71	4·90	20·00	5·10	2·12	·22
3-MD-56	" " II "	Aug. 26	·19	30·69	5·22	3·83	14·47	4·18	·84	·12
3-MD-21	Fourth priming leaves—Late vegetative	July 22	·50	30·15	4·78	16·29	37·35	11·82	2·35	·13
3-MD-27	" Early bud	July 24	·42	18·07	10·69	12·11	17·12	7·57	1·42	·07
3-MD-34	" Early bloom	July 27	·57	18·77	7·11	10·67	26·48	5·93	·69	·16
3-MD-40	" Late bloom	Aug. 7	·21	23·62	6·47	6·37	28·40	5·06	2·91	·11
3-MD-45	" Harvesting I—Unprimed	Aug. 15	·15	29·00	6·55	4·58	23·11	5·14	3·93	·14
3-MD-54	" " II "	Aug. 26	·11	22·08	4·06	2·35	15·23	3·17	4·95	·15
3-MD-62	" " III "	Sept. 10	·16	41·91	6·23	4·13	3·16	4·37	3·32	·16
3-MD-49	" " I—Primed	Aug. 15	·18	22·06	4·58	3·80	14·40	4·01	3·51	·19
3-MD-57	" " II "	Aug. 26	·12	26·84	4·97	2·89	8·11	3·02	2·14	·11
3-MD-64	" " III "	Sept. 10	·15	40·16	6·34	3·28	4·88	3·43	4·52	·19
3-MD-28	Tops—Early bud	July 24	·57	49·70	24·98	17·10	27·43	11·77	·68	·08
3-MD-35	" Early bloom	July 27	·27	9·03	4·30	6·41	8·61	5·40	·25	·07
3-MD- 2	Stalks—Seedling stage	June 5	·13	10·03	3·04	3·43	45·92	2·95	15·51	·10
3-MD- 6	" Early growth	July 3	·69	10·87	4·65	4·59	25·27	4·15	4·27	·08
3-MD-11	" Intermediate	July 16	·25	12·69	3·83	4·19	37·58	3·83	2·93	·01
3-MD-16	" Mid-vegetative	July 19	·29	12·21	4·07	5·05	28·99	5·62	4·40	·05
3-MD-22	" Late vegetative	July 22	·26	15·83	4·05	5·49	25·90	5·85	3·06	·07
3-MD-29	" Early bud	July 24	·25	17·12	6·66	5·60	24·63	5·81	3·28	·02
3-MD-36	" Early bloom	July 27	·25	17·12	5·13	5·34	20·94	4·03	2·51	·07
3-MD-41	" Late bloom	Aug. 7	·21	22·19	6·52	5·41	30·24	7·21	3·19	·07
3-MD-46	" Harvesting I—Unprimed	Aug. 15	·15	20·47	6·41	6·27	14·90	6·82	5·43	·03
3-MD-55	" " II "	Aug. 26	·13	17·25	3·52	3·52	17·77	4·64	4·72	·08
3-MD-63	" " III "	Sept. 10	·21	32·31	6·27	6·27	9·19	6·41	3·90	·13
3-MD-50	" " I—Primed	Aug. 15	·17	18·49	3·74	2·87	5·17	4·12	3·64	·07
3-MD-58	" " II "	Aug. 26	·11	16·90	4·31	3·28	5·00	5·69	3·53	·04
3iMD-65	" " III "	Sept. 10	·49	30·75	6·57	10·51	20·63	5·91	8·15	·04

TABLE 22.—MINERAL-INTAKE EXPERIMENT—DELHI, 1940 (FLUE-CURED TOBACCO)

Lab. No.	Description of Sample	Date of Sampling	Green Matter Basis											
			Moisture	Dry matter	Ash	Fe_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4	N
3-MD- 1	Bottom leaves—Seedling stage	June 5	93·2	6·8	1·749	·004	·262	·078	·073	·450	·116	·171	·0041	·338
3-MD- 3	" Early growth	July 3	84·7	15·3	2·789	·011	·780	·145	·086	·667	·109	·093	·0026	·344
3-MD- 7	" Intermediate	July 16	86·8	13·2	3·241	·015	·962	·186	·071	·612	·148	·034	·0037	·252
3-MD-12	" Mid-vegetative	July 19	86·4	13·6	2·817	·012	·953	·143	·075	·487	·152	·020	·0054	....
3-MD-17	" Late vegetative	July 22	86·6	13·4	2·913	·014	1·100	·173	·094	·874	·138	·042	·0042	....
3-MD-23	" Early bud	July 24	87·3	12·7	2·971	·012	1·092	·182	·075	·215	·142	·060	·0027	....
3-MD-30	" Early bloom	July 27	87·1	12·9	2·877	·013	1·017	·209	·077	·266	·164	·065	·0044	....
3-MD- 4	First priming leaves—Early growth	July 3	80·3	19·7	3·308	·020	·487	·160	·165	·810	·156	·057	·0030	·528
3-MD- 8	" Intermediate	July 16	86·1	13·9	2·690	·008	·648	·111	·054	·559	·111	·026	·0025	·278
3-MD-13	" Mid-vegetative	July 19	85·2	14·8	2·417	·011	·743	·124	·092	·195	·152	·024	·0033	·318
3-MD-18	" Late vegetative	July 22	84·5	15·5	2·441	·008	·763	·127	·112	·344	·135	·016	·0020	·279
3-MD-24	" Early bud	July 24	84·4	15·6	2·387	·009	·763	·122	·090	·479	·105	·011	·0020	·248
3-MD-31	" Early bloom	July 27	84·6	15·4	2·447	·010	·733	·145	·097	·268	·136	·005	·0028	·242
3-MD-37	" Late bloom	Aug. 7	82·3	17·7	2·786	·009	·915	·165	·101	·366	·140	·005	·0051	·255
3-MD-42	" Harvesting I—Unprimed.	Aug. 15	82·1	17·9	2·851	·008	1·081	·174	·086	·435	·136	·013	·0043	·231
3-MD-51	" " II "	Aug. 26	81·2	18·8	2·969	·009	1·077	·150	·122	·447	·090	·030	·0055	·216
3-MD-59	" " III "	Sept. 10	81·6	18·4	3·327	·008	1·163	·186	·153	·418	·109	·013	·0057	·221
3-MD- 5	Second priming leaves—Early growth	July 3	83·6	16·4	2·457	·023	·300	·166	·205	·730	·141	·069	·0034	....
3-MD- 9	" Intermediate	July 16	87·3	12·7	2·172	·004	·307	·072	·104	·490	·084	·028	·0008	·405
3-MD-14	" Mid-vegetative	July 19	86·2	13·8	1·692	·006	·362	·052	·080	·348	·104	·026	·0023	·392
3-MD-19	" Late vegetative	July 22	86·4	13·6	1·754	·005	·412	·083	·106	·466	·073	·020	·0016	·384
3-MD-25	" Early bud	July 24	84·9	15·1	2·091	·004	·467	·125	·098	·390	·085	·018	·0002	·321
3-MD-32	" Early bloom	July 27	84·1	15·9	1·976	·007	·488	·121	·092	·385	·103	·005	·0024	·370
3-MD-38	" Late bloom	Aug. 7	80·6	19·4	2·179	·006	·640	·175	·095	·405	·099	·014	·0021	·355
3-MD-43	" Harvesting I—Unprimed	Aug. 15	79·3	20·7	2·258	·005	·789	·132	·091	·470	·106	·014	·0033	·302
3-MD-52	" " II "	Aug. 26	78·0	22·0	2·834	·004	·823	·158	·108	·198	·207	·048	·0046	·299
3-MD-60	" " III "	Sept. 10	78·9	21·1	3·106	·007	·990	·146	·127	·112	·097	·021	·0042	·281
3-MD-47	" " I—Primed...	Aug. 15	80·1	19·9	2·370	·004	·828	·115	·107	·392	·113	·020	·0038	·326
3-MD-10	Third priming leaves—Intermediate	July 16	89·0	11·0	1·401	·004	·321	·123	·173	·446	·107	·033	·0009	....
3-MD-15	" Mid-vegetative	July 19	87·5	12·5	1·461	·007	·258	·066	·146	·144	·100	·038	·0005	....
3-MD-20	" Late vegetative	July 22	87·8	12·2	1·230	·004	·242	·081	·148	·346	·087	·015	·0013	....
3-MD-26	" Early bud	July 24	85·3	14·7	1·682	·004	·313	·097	·122	·270	·093	·028	·0010	·515
3-MD-33	" Early bloom	July 27	84·3	15·7	1·959	·008	·350	·118	·119	·305	·082	·019	·0022	·512
3-MD-39	" Late bloom	Aug. 7	79·1	20·9	2·086	·005	·564	·134	·105	·347	·100	·038	·0029	·477
3-MD-44	" Harvesting 1—Unprimed.	Aug. 15	78·6	21·4	2·251	·004	·749	·148	·092	·484	·105	·047	·0034	·387

3-MD-53	" " II "	Aug. 26	80·9	19·1	2·294	·003	·672	·109	·090	·434	·088	·073	·0040	·308
3-MD-61	" " III "	Sept. 10	77·6	22·4	2·569	·005	1·024	·175	·125	·103	·121	·049	·0047	·311
3-MD-48	" " I—Primed....	Aug. 15	79·5	20·5	2·132	·004	·650	·100	·105	·426	·109	·045	·0047	·398
3-MD-56	" " II "	Aug. 26	76·9	23·1	3·319	·006	1·019	·173	·127	·480	·139	·028	·0039	·356
3-MD-21	Fourth priming leaves—Late vegetative..........	July 22	88·6	11·4	1·456	·007	·439	·070	·237	·544	·172	·034	·0018	....
3-MD-27	" Early bud..............	July 24	85·5	14·5	1·533	·006	·277	·164	·186	·262	·116	·022	·0010	....
3-MD-34	" Early bloom............	July 27	83·1	16·9	1·710	·010	·321	·122	·183	·453	·101	·012	·0027	....
3-MD-40	" Late bloom..............	Aug. 7	81·7	18·3	1·953	·004	·766	·141	·081	·528	·110	·172	·0053	·575
3-MD-45	" Harvesting I—Unprimed	Aug. 15	79·5	20·5	2·191	·003	·636	·144	·100	·506	·113	·086	·0031	·476
3-MD-54	" " II "	Aug. 26	78·0	22·0	3·467	·004	·766	·141	·081	·528	·110	·172	·0053	·431
3-MD-62	" " III "	Sept. 10	77·5	22·5	2·781	·005	1·166	·173	·115	·088	·122	·092	·0045	·376
3-MD-49	" " I—Primed...	Aug. 15	79·9	20·1	2·806	·005	·619	·129	·107	·404	·113	·098	·0052	·505
3-MD-57	" " II " ...	Aug. 26	78·2	21·8	3·468	·004	·931	·172	·100	·281	·105	·074	·0039	·447
3-MD-64	" " III " ...	Sept. 10	79·4	20·6	2·826	·004	1·135	·179	·093	·138	·097	·128	·0054	·406
3-MD-28	Tops—Early bud..................................	July 24	87·4	12·6	1·488	·008	·740	·372	·255	·408	·175	·010	·0011	....
3-MD-35	" Early bloom............................	July 27	87·2	12·8	1·517	·004	·137	·065	·097	·131	·082	·004	·0010	....
3-MD- 2	Stalks—Seedling stage.........................	June 5	94·8	5·2	1·197	·002	·120	·036	·041	·550	·035	·186	·0011	....
3-MD- 6	" Early growth...........................	July 3	87·3	12·7	2·021	·014	·220	·094	·093	·511	·084	·086	·0015	·221
3-MD-11	" Intermediate...........................	July 16	92·2	7·8	1·303	·003	·165	·050	·055	·490	·165	·038	·0002	·121
3-MD-16	" Mid-vegetative.........................	July 19	91·1	8·9	1·093	·003	·134	·045	·055	·317	·061	·048	·0005	·136
3-MD-22	" Late vegetative........................	July 22	90·4	9·6	1·068	·003	·169	·043	·059	·276	·062	·033	·0008	·123
3-MD-29	" Early bud..............................	July 24	88·9	11·1	1·050	·003	·180	·070	·059	·259	·061	·034	·0002	·131
3-MD-36	" Early bloom............................	July 27	86·0	14·0	1·284	·003	·220	·066	·069	·269	·052	·032	·0008	·137
3-MD-41	" Late bloom.............................	Aug. 7	83·1	16·9	1·218	·003	·270	·079	·066	·268	·088	·039	·0008	·161
3-MD-46	" Harvesting I—Unprimed.............	Aug. 15	85·1	14·9	1·070	·002	·319	·069	·067	·159	·073	·058	·0003	·148
3-MD-55	" " II "	Aug. 26	83·2	16·8	1·957	·003	·338	·069	·069	·348	·091	·092	·0015	·155
3-MD-63	" " III "	Sept. 10	81·6	18·4	1·321	·003	·427	·083	·083	·121	·085	·052	·0017	·142
3-MD-50	" " I—Primed.................	Aug. 15	85·6	14·4	1·503	·003	·289	·056	·043	·078	·062	·055	·0010	·120
3-MD-58	" " II "	Aug. 26	83·8	16·2	1·879	·002	·318	·081	·062	·094	·107	·066	·0008	·144
3-MD-65	" " III "	Sept. 10	84·0	16·0	1·218	·006	·374	·080	·128	·251	·072	·099	·0005	·139

TABLE 23.—MINERAL-INTAKE EXPERIMENT—DELHI, 1940 (FLUE-CURED TOBACCO)

Lab. No.	Description of Sample	Date of sampling	Absolute Weight per Plant in Grams												
			Total green weight	Moisture	Dry weight	Ash	Fe_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4	N
3-MD- 1	Bottom leaves—Seedling stage	June 5	3·6	3·4	·24	·0630	·0001	·0094	·0028	·0026	·0162	·0041	·0062	·000148	·0122
3-MD- 3	" Early growth	July 3	14·3	12·1	2·19	·3988	·0016	·1115	·0207	·0123	·0954	·0156	·0133	·000372	·0492
3-MD- 7	" Intermediate	July 16	22·7	19·7	3·00	·7357	·0034	·2184	·0422	·0161	·1389	·0336	·0077	·000840	·0572
3-MD-12	" Mid-vegetative	July 19	19·3	16·7	2·62	·5437	·0023	·1839	·0276	·0145	·0940	·0293	·0039	·001042	....
3-MD-17	" Late vegetative	July 22	26·3	22·8	3·52	·7661	·0037	·2893	·0455	·0247	·2299	·0363	·0110	·001105	....
3-MD-23	" Early bud	July 24	23·2	20·3	2·95	·6893	·0028	·2533	·0422	·0174	·0499	·0330	·0139	·000626	....
3-MD-30	" Early bloom	July 27	30·8	26·8	3·97	·8861	·0040	·3132	·0644	·0237	·0819	·0505	·0200	·001355	....
3-MD- 4	First priming leaves—Early growth	July 3	29·1	23·4	5·73	·9626	·0058	·1417	·0466	·0480	·2357	·0454	·0166	·000873	·1586
3-MD- 8	" Intermediate	July 16	66·1	67·9	9·19	1·7781	·0052	·4283	·0734	·0357	·3695	·0734	·0172	·001653	·1838
3-MD-13	" Mid-vegetative	July 19	59·9	51·0	8·87	1·4478	·0066	·4451	·0743	·0551	·1168	·0910	·0144	·001977	·1905
3-MD-18	" Late vegetative	July 22	69·7	58·9	10·80	1·7014	·0056	·5318	·0885	·0781	·2398	·0941	·0112	·001394	·1945
3-MD-24	" Early bud	July 24	68·2	57·6	10·64	1·6279	·0061	·5204	·0832	·0614	·3267	·0716	·0075	·001364	·1691
3-MD-31	" Early bloom	July 27	87·1	73·7	13·41	2·1313	·0087	·6384	·1263	·0845	·2334	·1185	·0049	·002439	·2108
3-MD-37	" Late bloom	Aug. 7	78·6	64·7	13·91	2·1898	·0071	·7192	·1297	·0794	·2877	·1100	·0039	·004009	·2004
3-MD-42	" Harvesting— I—Unprimed	Aug. 15	76·2	62·6	13·64	2·1725	·0061	·8237	·1326	·0655	·3315	·1036	·0099	·003277	·1760
3-MD-51	" II "	Aug. 26	84·0	68·2	15·79	2·4940	·0076	·9047	·1260	·1025	·3755	·0756	·0252	·004620	·1814
3-MD-59	" III "	Sept. 10	95·2	77·7	17·52	3·1673	·0076	1·1072	·1771	·1457	·3979	·1038	·0124	·005426	·2104
3-MD- 5	Second priming leaves—Early growth	July 3	2·5	2·1	·41	·0614	·0006	·0075	·0042	·0051	·0183	·0035	·0017	·000085	....
3-MD- 9	" Intermediate	July 16	49·2	43·0	6·25	1·0686	·0020	·1510	·0354	·0512	·2411	·0413	·0138	·000394	·1993
3-MD-14	" Mid-vegetative	July 19	75·0	64·7	10·46	1·2690	·0045	·2715	·0390	·0600	·2610	·0780	·0195	·001725	·2940
3-MD-19	" Late vegetative	July 22	67·7	58·5	9·21	1·1875	·0034	·2789	·0562	·0718	·3155	·0494	·0135	·001083	·2600
3-MD-25	" Early bud	July 24	78·2	66·4	11·81	1·6352	·0031	·3652	·0978	·0766	·3050	·0665	·0141	·000156	·2510
3-MD-32	" Early bloom	July 27	79·0	66·4	12·56	1·5610	·0055	·3855	·0956	·0727	·3042	·0814	·0040	·001896	·2923
3-MD-38	" Late bloom	Aug. 7	87·2	70·3	16·92	1·9001	·0052	·5581	·1526	·0828	·3532	·0863	·0122	·001831	·3096
3-MD-43	" Harvesting— I—Unprimed	Aug. 15	90·6	71·8	18·75	2·0457	·0045	·7148	·1196	·0824	·4258	·0960	·0127	·002990	·2736
3-MD-52	" II "	Aug. 26	105·9	82·6	23·30	3·0012	·0042	·8716	·1673	·1144	·2097	·2192	·0508	·004871	·3166
3-MD-60	" III "	Sept. 10	112·7	88·9	23·78	3·5005	·0079	1·1157	·1645	·1431	·1262	·1093	·0237	·004733	·3167
3-MD-47	" I—Primed	Aug. 15	122·6	98·2	24·40	2·9056	·0049	1·0151	·1410	·1312	·4806	·1385	·0245	·004659	·3997
3-MD-10	Third priming leaves—Intermediate	July 16	4·7	4·2	·52	·0658	·0002	·0151	·0058	·0081	·0210	·0050	·0016	·000042	....
3-MD-15	" Mid-vegetative	July 19	17·5	15·3	2·19	·2557	·0012	·0452	·0116	·0256	·0252	·0175	·0067	·000088	....
3-MD-20	" Late vegetative	July 22	27·1	23·8	3·31	·3333	·0011	·0656	·0220	·0401	·0938	·0236	·0041	·000352	....
3-MD-26	" Early bud	July 24	45·0	38·4	6·62	·7569	·0018	·1409	·0437	·0549	·1215	·0419	·0126	·000450	·2318
3-MD-33	" Early bloom	July 27	45·0	37·9	7·07	·8816	·0036	·1575	·0531	·0536	·1373	·0369	·0086	·000990	·2304
3-MD-39	" Late bloom	Aug. 7	68·7	54·3	14·36	1·4331	·0034	·3875	·0921	·0721	·2384	·0687	·0261	·001992	·3277
3-MD-44	" Harvesting— I—Unprimed	Aug. 15	83·6	65·7	17·90	1·8818	·0033	·6262	·1237	·0769	·4046	·0878	·0393	·002842	·3235

3-MD-53	" II "	Aug. 26	98·0	79·3	18·72	2·2481	·0029	·6586	·1068	·0882	·4253	·0862	·0715	·003920	·3018
3-MD-61	" III "	Sept. 10	110·4	85·7	24·73	2·8362	·0055	1·1305	·1932	·1380	·1137	·1336	·0541	·005189	·3433
3-MD-48	" I—Primed...	Aug. 15	103·4	82·2	21·20	2·2045	·0041	·6721	·1034	·1086	·4405	·1127	·0465	·004860	·4105
3-MD-56	" II " ...	Aug. 26	97·9	75·3	22·61	3·2493	·0059	·9976	·1694	·1243	·4699	·1361	·0274	·003818	·3485
3-MD-21	Fourth priming leaves—Late vegetative	July 22	3·7	3·3	·42	·0539	·0003	·0162	·0026	·0088	·0201	·0064	·0013	·000067	....
3-MD-27	" Early bud......	July 24	11·0	9·4	1·60	·1686	·0007	·0305	·0180	·0205	·0288	·0128	·0024	·000110	....
3-MD-34	" Early bloom....	July 27	14·4	12·0	2·43	·2462	·0014	·0462	·0176	·0264	·0652	·0145	·0017	·000389	....
3-MD-40	" Late bloom.....	Aug. 7	47·7	39·0	8·73	·9316	·0019	·2199	·0601	·0591	·2643	·0472	·0272	·001049	·2743
3-MD-45	" Harvesting— " I—Unprimed	Aug. 15	76·7	61·0	15·72	1·6805	·0023	·4878	·1104	·0767	·3881	·0867	·0660	·002378	·3651
3-MD-54	" II " .	Aug. 26	74·2	57·9	16·32	2·5725	·0030	·5684	·1046	·0601	·3918	·0817	·1276	·003933	·3198
3-MD-62	" III " .	Sept. 10	74·7	57·9	16·81	2·0774	·0037	·8710	·1292	·0859	·0657	·0911	·0687	·003362	·2809
3-MD-49	" I—Primed...	Aug. 15	96·1	76·8	19·32	2·6966	·0048	·5949	·1240	·1028	·3882	·1086	·0942	·004997	·4853
3-MD-57	" II " ...	Aug. 26	142·4	111·4	31·04	4·9384	·0057	1·3257	·2449	·1424	·4001	·1495	·1054	·005554	·6365
3-MD-64	" III " ...	Sept. 10	92·7	73·6	19·10	2·6197	·0037	1·0521	·1659	·0862	·1279	·0899	·1187	·005006	·3764
3-MD-28	Tops—Early bud........................	July 24	3·2	2·8	·40	·0476	·0003	·0237	·0119	·0082	·0131	·0056	·0003	·000035	....
3-MD-35	" Early bloom....................	July 27	13·4	11·7	1·72	·2033	·0005	·0184	·0087	·0130	·0176	·0110	·0005	·000134	....
3-MD- 2	Stalks—Seedling stage.................	June 5	1·5	1·4	·08	·0180	·0001	·0018	·0005	·0006	·0083	·0005	·0028	·000017	....
3-MD- 6	" Early growth..................	July 3	7·8	6·8	·99	·1576	·0011	·0172	·0073	·0073	·0399	·0066	·0067	·000117	·0172
3-MD-11	" Intermediate..................	July 16	43·7	40·3	3·41	·5694	·0013	·0721	·0219	·0240	·2141	·0721	·0166	·000087	·0529
3-MD-16	" Mid-vegetative................	July 19	64·5	58·8	5·74	·7050	·0019	·0864	·0290	·0355	·2045	·0393	·0310	·000323	·0877
3-MD-22	" Late vegetative...............	July 22	79·3	71·7	7·61	·8469	·0024	·1340	·0341	·0468	·2190	·0402	·0262	·000634	·0975
3-MD-29	" Early bud.....................	July 24	107·8	95·8	11·97	1·1319	·0032	·1940	·0755	·0636	·2792	·0658	·0367	·000216	·1412
3-MD-36	" Early bloom...................	July 27	144·3	124·1	20·20	1·8528	·0043	·3175	·0952	·0996	·3882	·0750	·0462	·001154	·1977
3-MD-41	" Late bloom....................	Aug. 7	159·1	132·2	26·89	1·9378	·0048	·4296	·1257	·1050	·4264	·1400	·0620	·001273	·2562
3-MD-46	" Harvesting— I—Unprimed.............	Aug. 15	236·4	201·2	35·22	2·5295	·0047	·5177	·1631	·1584	·3750	·1726	·1371	·000709	·3499
3-MD-55	" II "	Aug. 26	227·1	188·9	38·15	4·4443	·0068	·7676	·1567	·1567	·7903	·2067	·2089	·003407	·3520
3-MD-63	" III "	Sept. 10	251·9	205·6	46·35	3·3276	·0076	1·0756	·2091	·2091	·3048	·2141	·1310	·004282	·3577
3-MD-50	" I—Primed................	Aug. 15	194·3	155·3	27·98	2·9203	·0058	·5402	·1088	·0835	·1516	·1205	·1069	·001943	·2332
3-MD-58	" II "	Aug. 26	210·2	176·1	34·05	3·9497	·0042	·6684	·1703	·1303	·1976	·2249	·1387	·001682	·3027
3-MD-65	" III "	Sept. 10	246·9	207·4	39·50	3·0072	·0148	·9234	·1975	·3160	·6197	·1778	·2444	·001235	·3432
	Total plant—Seedling stage............	June 5	5·1	4·8	·32	·0810	·0002	·0112	·0033	·0032	·0245	·0046	·0090	·000165	....
	" Early growth.............	July 3	53·7	44·1	9·32	1·5804	·0091	·2779	·0788	·0727	·3893	·0711	·0383	·001447	....
	" Intermediate.............	July 16	186·4	164·4	22·37	4·2176	·0122	·8849	·1787	·1351	·9846	·2254	·0569	·003016	....
	" Mid-vegetative...........	July 19	236·2	206·5	29·77	4·2212	·0165	1·0321	·1815	·1907	·7015	·2551	·0755	·005125	....
	" Late vegetative..........	July 22	273·8	239·0	34·87	4·8891	·0165	1·3158	·2489	·2703	1·1180	·2590	·0673	·004635	....
	" Early bud................	July 24	336·6	290·7	45·99	6·0592	·0180	1·5280	·3723	·3026	1·1242	·2072	·0875	·002957	....
	" Early bloom..............	July 27	414·0	352·6	61·36	7·7623	·0280	1·8767	·4609	·3735	1·2278	·3878	·0854	·008357	....
	" Late bloom...............	Aug. 7	441·3	360·5	80·81	8·3924	·0224	2·3143	·5602	·3984	1·5700	·4522	·1314	·010153	....
	" Harvesting— " I—Unprimed.........	Aug. 15	563·5	462·3	101·22	10·3100	·0209	3·1702	·6494	·4599	1·9259	·5467	·2650	·012196	....
	" II "	Aug. 26	589·2	476·9	112·28	14·7601	·0245	3·7709	·6614	·5219	2·1926	·6694	·4840	·020751	....
	" III "	Sept. 10	644·9	515·8	129·19	14·9090	·0323	5·3000	·8731	·7218	1·0083	·6519	·2899	·022992	....
	" I—Primed...........	Aug. 15	516·4	423·5	92·90	10·7270	·0196	2·8223	·4772	·4261	1·4609	·4803	·2721	·016459	....
	" II "	Aug. 26	450·5	362·8	87·70	12·1374	·0158	2·9917	·5846	·3970	1·0676	·5105	·2715	·011054	....
	" III "	Sept. 10	339·6	281·0	58·60	5·6269	·0185	1·9755	·3634	·4022	·7476	·2677	·3631	·006241	....

TABLE 24.—MINERAL-INTAKE EXPERIMENT—HARROW, 1940 (Burley Tobacco)

Lab. No.	Description of Sample	Date of Sampling	Dry Matter Basis (Sand-free, Moisture-free)									
			Ash	Fe_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4	N
MH- 1	Bottom leaves—Seedling stage	May 31	25·23	·064	4·61	·78	1·56	8·29	2·30	·75	·013	....
MH- 3	" Early growth	July 2	17·30	·145	4·78	·97	·64	4·89	·58	1·59	·021	4·43
MH- 5	" Intermediate	July 15	22·68	·110	7·23	1·18	·51	5·58	·46	1·72	·012	4·07
MH- 8	" Mid-vegetative	July 23	23·73	·100	6·65	1·16	·50	6·23	·62	1·55	·031	3·82
MH-12	" Late vegetative	July 30	23·49	·076	6·22	·97	·57	6·96	·57	1·53	·052	3·82
MH-17	" Early bud	Aug. 7	20·76	·085	6·29	1·09	·46	2·80	·86	·80	·134	3·62
MH-22	" Early bloom	Aug. 12	23·15	·087	8·22	1·16	·41	1·62	·75	·81	·197	3·37
MH-27	" Late bloom	Aug. 19	22·79	·090	7·93	1·40	·48	3·52	·79	1·07	·118	3·27
MH-36	" Harvesting	Sept. 8	23·21	·119	8·41	1·71	·51	2·19	·72	·91	·185	3·62
MH-32	" Late bloom (topped)	Aug. 19	22·45	·084	8·05	1·72	·54	2·78	·57	1·09	·171	3·51
MH-41	" Harvesting (topped)	Sept. 8	23·69	·093	8·92	1·40	·51	1·55	·59	·92	·149	3·42
MH- 6	Middle leaves—Intermediate	July 15	17·81	·067	3·58	·74	·89	5·65	·51	1·27	·015	5·52
MH- 9	" Mid-vegetative	July 23	19·86	·068	4·16	·86	·73	5·18	·60	1·16	·011	5·65
MH-13	" Late vegetative	July 30	17·41	·052	3·98	·83	·71	3·37	·64	1·11	·031	4·63
MH-18	" Early bud	Aug. 7	16·57	·037	4·38	·75	·49	2·76	·73	·73	·126	4·16
MH-23	" Early bloom	Aug. 12	16·05	·046	4·85	·82	·53	2·67	·71	·51	·078	4·21
MH-28	" Late bloom	Aug. 19	16·47	·043	5·41	·99	·52	2·91	·68	·59	·058	4·12
MH-37	" Harvesting	Sept. 8	18·04	·042	6·80	1·11	·56	·99	·59	·63	·118	4·12
MH-33	" Late bloom (topped)	Aug. 19	17·14	·038	5·70	1·31	·58	1·85	·66	·93	·125	4·11
MH-42	" Harvesting (topped)	Sept. 8	19·36	·039	6·91	1·11	·56	2·15	·58	·69	·125	4·12
MH-10	Top leaves—Mid-vegetative	July 23	16·79	·045	2·53	·55	1·10	3·80	·60	·93	·020	5·53
MH-14	" Late vegetative	July 30	15·08	·047	2·61	·46	·98	2·34	·55	1·06	·024	5·42
MH-19	" Early bud	Aug. 7	13·40	·035	2·65	·59	·72	1·13	·73	·54	·062	4·68
MH-24	" Early bloom	Aug. 12	11·77	·032	3·01	·60	·73	2·02	·69	·41	·039	4·83
MH-29	" Late bloom	Aug. 19	13·35	·028	3·82	·87	·61	·60	·67	·56	·044	4·57
MH-38	" Harvesting	Sept. 8	16·89	·031	6·23	1·14	·54	1·14	·71	·81	·100	4·94
MH-34	" Late bloom (topped)	Aug. 19	13·58	·029	3·84	·87	·73	2·54	·63	·89	·079	4·86
MH-43	" Harvesting (topped)	Sept. 8	15·89	·028	5·70	·91	·53	1·83	·58	·74	·071	4·29
MH-15	Tops—Late vegetative	July 30	12·53	·048	2·72	·52	2·12	1·96	1·08	1·58	·012	....
MH-20	" Early bud	Aug. 7	11·34	·037	1·84	·66	1·51	1·69	·80	·64	·049	....
MH-25	" Early bloom	Aug. 12	11·07	·051	1·78	·81	1·37	1·70	·68	·66	·024	5·73
MH-30	" Late bloom	Aug. 19	10·59	·046	1·99	·73	1·02	1·11	·62	·78	·011	4·59
MH-39	" Harvesting	Sept. 8	9·78	·034	2·21	·53	·92	2·23	1·07	·62	·023	4·43
MH- 2	Stalks—Seedling stage	May 31	24·74	·051	3·90	·67	1·57	14·33	·87	1·97	·003	....
MH- 4	" Early growth	July 2	18·41	·182	2·52	·73	·72	6·13	·50	1·88	·013	....
MH- 7	" Intermediate	July 15	19·96	·061	2·53	·57	·77	5·56	·49	2·02	·008	3·39
MH-11	" Mid-vegetative	July 23	18·73	·045	2·26	·53	·75	4·98	·33	1·67	·013	3·26
MH-16	" Late vegetative	July 30	14·69	·033	2·01	·41	·66	3·41	·54	1·46	·011	2·71
MH-21	" Early bud	Aug. 7	12·23	·026	1·94	·37	·47	1·85	·53	·77	·028	2·24
MH-26	" Early bloom	Aug. 12	9·41	·022	1·94	·51	·42	1·66	·47	·56	·014	2·02
MH-31	" Late bloom	Aug. 19	9·09	·024	2·08	·53	·41	2·09	·59	·52	·014	1·67
MH-40	" Harvesting	Sept. 8	8·76	·063	2·45	·45	·32	·88	·35	·57	·031	2·16
MH-35	" Late bloom (topped)	Aug. 19	8·16	·018	1·74	·55	·46	1·95	·29	·65	·021	2·07
MH-44	" Harvesting (topped)	Sept. 8	8·12	·030	1·99	·60	·43	1·31	·54	·58	·045	2·36

TABLE 25.—MINERAL-INTAKE EXPERIMENT—HARROW, 1940 (BURLEY TOBACCO)

Lab. No.	Description of Sample	Date of Sampling	Percentage of Ash							
			Fe_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4
MH- 1	Bottom leaves—Seedling stage	May 31	·25	18·27	3·09	6·18	32·86	9·12	2·97	·05
MH- 3	" Early growth	July 2	·84	27·63	5·61	3·70	28·26	3·35	9·19	·12
MH- 5	" Intermediate	July 15	·49	31·88	10·10	2·25	24·60	2·03	7·58	·05
MH- 8	" Mid-vegetative	July 23	·42	28·02	4·89	2·11	26·25	2·61	6·53	·13
MH-12	" Late vegetative	July 30	·32	26·48	4·13	2·43	29·63	2·43	6·51	·22
MH-17	" Early bud	Aug. 7	·41	30·30	5·25	2·22	13·49	4·14	3·85	·65
MH-22	" Early bloom	Aug. 12	·38	35·51	5·01	1·77	7·00	3·24	3·50	·85
MH-27	" Late bloom	Aug. 19	·39	34·80	6·14	2·11	15·45	3·47	4·70	·52
MH-36	" Harvesting	Sept. 8	·51	36·23	7·37	2·20	9·44	3·10	3·92	·80
MH-32	" Late bloom (topped)	Aug. 19	·37	35·86	7·66	2·41	12·38	2·54	4·86	·76
MH-41	" Harvesting (topped)	Sept. 8	·39	37·65	5·91	2·15	6·54	2·49	3·88	·63
MH- 6	Middle leaves—Intermediate	July 15	·38	20·10	4·15	5·00	31·72	2·86	7·13	·08
MH- 9	" Mid-vegetative	July 23	·34	20·95	4·33	3·68	26·08	3·02	5·84	·06
MH-13	" Late vegetative	July 30	·30	22·86	4·77	4·08	19·36	3·68	6·38	·18
MH-18	" Early bud	Aug. 7	·22	26·43	4·53	2·96	16·66	4·41	4·41	·76
MH-34	" Early bloom	Aug. 12	·29	30·22	5·11	3·30	16·64	4·42	3·18	·49
MH-28	" Late bloom	Aug. 19	·26	32·85	6·01	3·16	17·67	4·13	3·58	·35
MH-37	" Harvesting	Sept. 8	·23	37·69	6·15	3·10	5·49	3·27	3·49	·65
MH-33	" Late bloom (topped)	Aug. 19	·22	33·26	7·64	3·38	10·79	3·85	5·43	·73
MH-42	" Harvesting (topped)	Sept. 8	·20	35·69	5·73	2·89	11·11	3·00	3·56	·65
MH-10	Top leaves—Mid-vegetative	July 23	·27	15·07	3·28	6·55	22·63	3·57	5·54	·12
MH-14	" Late vegetative	July 30	·31	17·31	3·05	6·50	15·52	3·65	7·03	·16
MH-19	" Early bud	Aug. 7	·26	19·78	4·40	5·37	8·43	5·45	4·03	·46
MH-24	" Early bloom	Aug. 12	·27	25·57	5·10	6·20	17·16	5·86	3·48	·33
MH-29	" Late bloom	Aug. 19	·21	28·61	6·52	4·57	4·49	5·02	4·19	·33
MH-38	" Harvesting	Sept. 8	·18	36·89	6·75	1·42	6·75	4·20	4·80	·59
MH-34	" Late bloom (topped)	Aug. 19	·21	28·28	6·41	5·38	18·70	4·64	6·55	·58
MH-43	" Harvesting (topped)	Sept. 8	·18	35·87	5·72	3·34	11·52	3·65	4·66	·45
MH-15	Tops—Late vegetative	July 30	·38	21·71	4·15	16·92	15·64	8·62	12·61	·10
MH-20	" Early bud	Aug. 7	·33	16·23	5·82	13·31	14·90	7·05	5·64	·43
MH-25	" Early bloom	Aug. 12	·46	16·08	7·32	12·38	15·36	6·14	5·96	·22
MH-30	" Late bloom	Aug. 19	·43	18·79	6·89	9·63	10·48	5·85	7·37	·10
MH-39	" Harvesting	Sept. 8	·35	22·60	5·42	9·41	22·80	10·94	6·34	·24
MH- 2	Stalks—Seedling stage	May 31	·21	15·76	2·71	6·35	57·92	3·52	7·96	·01
MH- 4	" Early growth	July 2	·99	13·69	3·97	3·91	33·30	2·72	10·21	·07
MH- 7	" Intermediate	July 15	·31	12·68	2·86	2·86	27·86	2·45	10·12	·04
MH-11	" Mid-vegetative	July 23	·24	12·07	2·83	2·83	26·59	1·76	8·92	·07
MH-16	" Late vegetative	July 30	·22	13·68	2·79	2·79	23·21	3·68	9·94	·07
MH-21	" Early bud	Aug. 7	·21	15·86	3·03	3·03	15·13	4·33	6·30	·23
MH-26	" Early bloom	Aug. 12	·23	20·62	5·42	5·42	17·64	4·99	5·95	·15
MH-31	" Late bloom	Aug. 19	·26	22·88	5·83	5·83	22·99	6·49	5·72	·15
MH-40	" Harvesting	Sept. 8	·72	27·97	5·14	5·14	10·05	4·00	6·51	·35
MH-35	" Late bloom (topped)	Aug. 19	·22	21·32	6·74	6·74	23·90	3·55	7·97	·26
MH-44	" Harvesting (topped)	Sept. 8	·37	24·51	7·39	7·39	16·13	6·65	7·14	·55

TABLE 26.—MINERAL-INTAKE EXPERIMENT—HARROW, 1940 (BURLEY TOBACCO)

Lab. No.	Description of Sample	Date of Sampling	Green Matter Basis											
			Moisture	Dry matter	Ash	Fe_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4	N
MH- 1	Bottom leaves—Seedling stage	May 31	84·6	15·4	3·885	·010	·710	·120	·240	1·277	·354	·116	·0020	....
MH- 3	" Early growth	July 2	86·2	13·8	2·387	·020	·660	·134	·088	·675	·080	·219	·0029	·611
MH- 5	" Intermediate	July 15	89·0	11·0	2·495	·012	·795	·130	·056	·614	·051	·189	·0013	·448
MH- 8	" Mid-vegetative	July 23	88·6	11·4	2·705	·011	·758	·132	·057	·710	·071	·177	·0035	·435
MH-12	" Late vegetative	July 30	88·8	11·2	2·631	·009	·697	·109	·064	·780	·064	·171	·0058	·428
MH-17	" Early bud	Aug. 7	87·4	12·6	2·616	·011	·793	·137	·058	·353	·108	·101	·0169	·456
MH-22	" Early bloom	Aug. 12	87·6	12·4	2·871	·011	1·019	·144	·051	·201	·093	·100	·0244	·418
MH-27	" Late bloom	Aug. 19	88·8	11·2	2·552	·010	·888	·157	·054	·394	·088	·120	·0132	·366
MH-36	" Harvesting	Sept. 8	88·8	11·2	2·600	·013	·942	·192	·057	·245	·081	·102	·0207	·405
MH-32	" Late bloom (topped)	Aug. 19	89·4	10·6	2·380	·009	·853	·183	·057	·295	·060	·116	·0181	·372
MH-41	" Harvesting (topped)	Sept. 8	90·0	10·0	2·369	·009	·892	·140	·051	·155	·059	·092	·0149	·342
MH- 6	Middle leaves—Intermediate	July 15	87·8	12·2	2·173	·008	·437	·090	·109	·689	·062	·155	·0018	·673
MH- 9	" Mid-vegetative	July 23	87·8	12·2	2·423	·008	·508	·105	·089	·632	·073	·142	·0013	·616
MH-13	" Late vegetative	July 30	88·6	11·4	1·985	·006	·454	·094	·081	·384	·073	·127	·0035	·528
MH-18	" Early bud	Aug. 7	87·0	13·0	2·154	·005	·569	·098	·064	·359	·095	·095	·0164	·541
MH-23	" Early bloom	Aug. 12	86·8	13·2	2·119	·006	·640	·108	·070	·352	·094	·067	·0103	·556
MH-28	" Late bloom	Aug. 19	87·2	12·8	2·108	·006	·692	·127	·067	·373	·087	·076	·0074	·527
MH-37	" Harvesting	Sept. 8	87·6	12·4	2·237	·005	·843	·138	·069	·123	·073	·078	·0146	·511
MH-33	" Late bloom (topped)	Aug. 19	88·0	12·0	2·057	·005	·684	·157	·070	·222	·079	·112	·0150	·493
MH-42	" Harvesting (topped)	Sept. 8	88·0	12·0	2·323	·005	·829	·133	·067	·258	·070	·083	·0150	·494
MH-10	Top leaves—Mid-vegetative	July 23	86·6	13·4	2·250	·006	·339	·074	·147	·509	·080	·125	·0027	·741
MH-14	" Late vegetative	July 30	90·4	9·6	1·448	·005	·251	·044	·094	·225	·053	·102	·0023	·520
MH-19	" Early bud	Aug. 7	88·0	12·0	1·608	·007	·318	·071	·086	·136	·088	·065	·0074	·562
MH-24	" Early bloom	Aug. 12	86·4	13·6	1·601	·004	·409	·082	·099	·275	·094	·056	·0053	·657
MH-29	" Late bloom	Aug. 19	85·6	14·4	1·951	·004	·550	·125	·088	·086	·096	·081	·0063	·658
MH-38	" Harvesting	Sept. 8	86·2	13·8	2·331	·004	·860	·157	·075	·157	·098	·112	·0138	·682
MH-34	" Late bloom (topped)	Aug. 19	84·8	15·2	2·064	·004	·584	·132	·111	·386	·096	·135	·0120	·739
MH-43	" Harvesting (topped)	Sept. 8	86·0	14·0	2·225	·004	·798	·127	·074	·256	·081	·104	·0099	·601
MH-15	Tops—Late vegetative	July 30	96·0	4·0	·501	·002	·109	·021	·085	·078	·043	·063	·0005	....
MH-20	" Early bud	Aug. 7	87·2	12·8	1·452	·005	·236	·084	·193	·216	·102	·082	·0063	....
MH-25	" Early bloom	Aug. 12	88·4	11·6	1·284	·006	·206	·094	·159	·197	·079	·077	·0028	·665
MH-30	" Late bloom	Aug. 19	87·4	12·6	1·334	·006	·251	·092	·129	·140	·078	·098	·0014	·578
MH-39	" Harvesting	Sept. 8	83·6	16·4	1·604	·006	·362	·087	·151	·366	·175	·102	·0038	·727
MH- 2	Stalks—Seedling stage	May 31	95·8	4·2	1·039	·002	·164	·028	·066	·602	·037	·083	·0001	....
MH- 4	" Early growth	July 2	87·4	12·6	2·320	·023	·318	·092	·091	·772	·063	·237	·0016	....
MH- 7	" Intermediate	July 15	93·6	6·4	1·277	·004	·162	·036	·049	·356	·031	·129	·0005	·217
MH-11	" Mid-vegetative	July 23	89·2	10·8	2·023	·005	·244	·057	·081	·538	·036	·180	·0014	·352
MH-16	" Late vegetative	July 30	92·4	7·6	1·116	·003	·153	·031	·050	·259	·041	·111	·0008	·206
MH-21	" Early bud	Aug. 7	89·8	10·2	1·247	·003	·198	·038	·048	·189	·054	·079	·0029	·228
MH-26	" Early bloom	Aug. 12	89·6	10·4	·979	·002	·202	·053	·044	·173	·049	·058	·0015	·210
MH-31	" Late bloom	Aug. 19	87·2	12·8	1·164	·003	·266	·068	·052	·268	·076	·067	·0018	·214
MH-40	" Harvesting	Sept. 8	86·4	13·6	1·191	·009	·333	·061	·044	·120	·048	·078	·0042	·294
MH-35	" Late bloom (topped)	Aug. 19	87·4	12·6	1·028	·002	·219	·069	·058	·246	·037	·082	·0026	·261
MH-44	" Harvesting (topped)	Sept. 8	86·2	13·8	1·121	·004	·275	·083	·059	·181	·075	·080	·0062	·326

TABLE 27.—MINERAL-INTAKE EXPERIMENT—HARROW, 1940 (BURLEY TOBACCO)

Lab. No.	Description of Sample	Date of Sampling	Total green weight	Mois-ture	Dry	Ash	Fe_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4	N
			Absolute Weight per Plant in Grams												
MH- 1	Bottom leaves—Seedling stage	May 31	1·2	1·0	·1848	·0466	·0001	·0085	·0014	·0029	·0153	·3239	·0014	·000024	....
MH- 3	" Early growth	July 2	32·0	27·6	4·4160	·7638	·0064	·2112	·0429	·0282	·2160	·0256	·0701	·000928	·1955
MH- 5	" Intermediate	July 15	84·2	74·9	9·2620	2·1008	·0101	·6694	·1095	·0472	·5158	·0428	·1588	·001092	·3772
MH- 8	" Mid-vegetative	July 23	116·8	103·5	13·3152	3·5194	·0128	·8853	·1542	·0666	·8293	·0829	·2067	·004088	·5081
MH-12	" Late vegetative	July 30	126·8	112·6	14·2016	3·3361	·0114	·8838	·1382	·0812	·9890	·0812	·2168	·007354	·5427
MH-17	" Early bud	Aug. 7	178·9	156·4	22·5414	4·6800	·0197	1·4187	·2451	·1038	·6315	·1932	·1807	·030234	·8158
MH-22	" Early bloom	Aug. 12	222·0	194·5	27·5280	6·3736	·0244	2·2622	·3197	·1132	·4462	·2065	·2220	·054168	·9280
MH-27	" Late bloom	Aug. 19	282·0	250·4	31·5840	7·1966	·0282	2·5042	·4427	·1523	1·1111	·2482	·3384	·037224	1·0321
MH-36	" Harvesting	Sept. 8	311·2	276·3	34·8544	8·0912	·0405	2·9315	·5975	·1774	·7624	·2521	·3174	·064418	1·2604
MH-32	" Late bloom (topped)	Aug. 19	332·3	297·1	35·2238	7·9087	·0299	2·8345	·6081	·1894	·9803	·1994	·3855	·060146	1·2362
MH-41	" Harvesting (topped)	Sept. 8	406·5	365·9	40·6500	9·6300	·0366	3·6260	·5691	·2073	·6301	·2398	·3740	·060569	1·3902
MH- 6	Middle leaves—Intermediate	July 15	90·3	79·3	11·0166	1·9622	·0072	·3946	·0813	·0984	·6222	·0560	·1400	·001625	·6077
MH- 9	" Mid-vegetative	July 23	146·7	128·8	17·8974	3·5545	·0117	·7452	·1540	·1306	·9271	·1071	·2083	·001907	·9037
MH-13	" Late vegetative	July 30	140·4	124·4	16·0056	2·7869	·0084	·6374	·1320	·1137	·5391	·1025	·1783	·004914	·7413
MH-18	" Early bud	Aug. 7	268·5	233·6	34·9050	5·7835	·0134	1·5278	·2631	·1718	·9639	·2551	·2551	·044034	1·4526
MH-23	" Early bloom	Aug. 12	341·5	296·4	45·0780	7·2364	·0205	2·1856	·3688	·2391	1·2021	·2872	·2288	·035175	1·8987
MH-28	" Late bloom	Aug. 19	330·1	287·8	42·2528	6·9585	·0198	2·2843	·4192	·2212	1·2313	·2872	·2509	·024427	1·7396
MH-37	" Harvesting	Sept. 8	387·5	339·5	48·2522	8·6684	·0194	3·2666	·5348	·2674	·4766	·2829	·3023	·056575	1·9801
MH-33	" Late bloom (topped)	Aug. 19	360·9	317·6	43·3080	7·4237	·0180	2·4686	·5666	·2526	·8012	·2851	·4042	·054135	1·7792
MH-42	" Harvesting (topped)	Sept. 8	403·7	355·3	48·4440	9·3780	·0202	3·3467	·5369	·2705	1·0415	·2826	·3351	·060555	1·9943
MH-10	Top leaves—Mid-vegetative	July 23	60·3	52·2	8·0802	1·3568	·0036	·2044	·0446	·0886	·3069	·0482	·0754	·001628	·4468
MH-14	" Late vegetative	July 30	92·7	83·8	8·8892	1·3923	·0046	·2327	·0408	·0871	·2086	·0491	·0946	·002132	·4820
MH-19	" Early bud	Aug. 7	162·3	142·8	19·4760	2·6098	·0114	·5161	·1152	·1396	·2207	·1428	·1055	·012010	·9121
MH-24	" Early bloom	Aug. 12	194·1	167·7	26·3976	3·1075	·0078	·7939	·1592	·1922	·5338	·1825	·1087	·010287	1·2752
MH-29	" Late bloom	Aug. 19	278·1	238·1	40·0464	5·4257	·0111	1·5296	·3476	·2447	·2392	·2670	·2253	·017520	1·8299
MH-38	" Harvesting	Sept. 8	289·8	249·8	39·9924	6·7552	·0116	2·4923	·4550	·2174	·4550	·2840	·3246	·039992	1·9764
MH-34	" Late bloom (topped)	Aug. 19	332·3	281·8	50·5096	6·8587	·0133	1·9406	·4386	·3689	1·2827	·3190	·4486	·039876	2·4557
MH-43	" Harvesting (topped)	Sept. 8	342·2	294·3	47·9080	7·6140	·0137	2·7308	·4346	·2532	·8760	·2772	·3559	·033878	2·0566

TABLE 27.—MINERAL-INTAKE EXPERIMENT—HARROW, 1940 (BURLEY TOBACCO)—*Concluded*

Lab. No.	Description of Sample	Date of Sampling	Absolute Weight per Plant in Grams												
			Total green weight	Moisture	Dry	Ash	Fe_2O_3	CaO	MgO	P_2O_5	K_2O	S	Cl	Mn_3O_4	N
MH-15	Tops—Late vegetative	July 30	7·5	7·2	·3000	·0376	·0002	·0082	·0016	·0064	·0059	·0032	·0047	·000038	....
MH-20	" Early bud	Aug. 7	38·9	33·9	4·9792	·5648	·0019	·0918	·0327	·0751	·0840	·0397	·0319	·002451	....
MH-25	" Early bloom	Aug. 12	105·3	93·1	12·2148	1·3521	·0063	·2169	·0990	·1674	·2074	·0832	·0811	·002948	·7002
MH-30	" Late bloom	Aug. 19	261·5	228·6	32·9490	3·4884	·0157	·6564	·2406	·3373	·3661	·2040	·2563	·003661	1·5115
MH-39	" Harvesting	Sept. 8	460·9	385·3	75·5876	7·3928	·0277	1·6685	·4010	·6960	1·6869	·8066	·4701	·017514	3·3507
MH- 2	Stalks—Seedling stage	May 31	1·2	1·1	·0504	·0125	·0001	·0020	·0003	·0008	·0072	·0004	·0010	·000001	....
MH- 4	" Early growth	July 2	2·3	2·0	·2898	·0534	·0005	·0073	·0021	·0021	·0178	·0014	·0055	·000037	....
MH- 7	" Intermediate	July 15	37·8	35·4	2·4192	·4827	·0015	·0612	·0136	·0185	·1346	·0117	·0488	·000189	·0820
MH-11	" Mid-vegetative	July 23	89·2	79·6	9·6336	1·8045	·0045	·2176	·0508	·0723	·4799	·0321	·1606	·001249	·3140
MH-16	" Late vegetative	July 30	135·2	124·9	10·2752	1·5088	·0041	·2069	·0419	·0676	·3502	·0554	·1501	·001082	·2785
MH-21	" Early bud	Aug. 7	298·2	267·8	30·4164	3·7186	·0089	·5904	·1133	·1431	·5636	·1610	·2356	·008648	·6799
MH-26	" Early bloom	Aug. 12	417·2	373·8	43·3888	4·0844	·0083	·8427	·2211	·1836	·7218	·2044	·2420	·006258	·8761
MH-31	" Late bloom	Aug. 19	558·7	487·2	71·5136	6·5033	·0168	1·4861	·3799	·2905	1·4973	·4296	·3743	·010057	1·1956
MH-40	" Harvesting	Sept. 8	669·2	578·2	91·0112	7·9702	·0602	2·2284	·4082	·2944	·8030	·3212	·5220	·028106	1·9674
MH-35	" Late bloom (topped)	Aug. 19	602·1	526·2	75·8646	6·1896	·0120	1·3186	·4154	·3492	1·4812	·2228	·4937	·015655	1·5715
MH-44	" Harvesting (topped)	Sept. 8	699·0	602·5	96·4620	7·8358	·0280	1·9223	·5802	·4124	1·2652	·5243	·5592	·043338	2·2787
	Total plants—Seedling stage	May 31	2·4	2·1	·2352	·0591	·0002	·0105	·0017	·0037	·0225	·0046	·0024	·000025	....
	" Early growth	July 2	34·3	29·6	4·7058	·8172	·0069	·2185	·0450	·0303	·2338	·0270	·0756	·000965	....
	" Intermediate	July 15	212·3	189·6	22·6978	4·5457	·0188	1·1252	·2044	·1641	1·2726	·1105	·3476	·002906	1·0669
	" Mid-vegetative	July 23	413·0	364·1	48·9264	9·8752	·0326	2·0525	·4036	·3581	2·5432	·2703	·6510	·008872	2·1726
	" Late vegetative	July 30	502·6	452·9	49·6816	9·0117	·0287	1·9690	·3545	·3560	2·0928	·2914	·6445	·015520	2·0445
	" Early bud	Aug. 7	946·8	834·5	112·3180	17·3567	·0553	4·1448	·7694	·6334	2·4637	·7918	·8088	·097377	3·8604
	" Early bloom	Aug. 12	1280·1	1125·5	154·6072	22·1540	·0673	6·3013	1·1678	·8955	3·1113	·9976	·8826	·108836	5·6782
	" Late bloom	Aug. 19	1710·4	1492·1	218·3458	29·5725	·0916	8·4606	1·8300	1·2460	4·4450	1·4310	1·4452	·092889	7·3087
	" Harvesting	Sept. 8	2118·6	1829·1	289·4956	38·8788	·1594	12·5873	2·3965	1·6526	4·1839	1·9468	1·9364	·206605	10·5350
	" Late bloom (topped)	Aug. 19	1627·6	1422·7	204·9060	28·3807	·0732	8·5623	2·0287	1·1601	4·5454	1·0263	1·7320	·169812	7·0426
	" Harvesting (topped)	Sept. 8	1851·4	1618·0	233·4640	34·4578	·0985	11·6258	2·1208	1·1434	3·8128	1·3239	1·6242	·198340	7·7198